2015

# Minds-In-Motion Maze Movement Activities in the Regular Education Classroom

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A dissertation submitted to the faculty of Bethel University in partial fulfillment of the requirements for the degree of Doctor of Education.

St. Paul, MN
2015

Approved by,

# Abstract

Movement is important for brain development. This qualitative, multi-case study investigated the effects of the Minds-In-Motion Maze targeted movement program on the students at a small, private school in the Midwest. Case studies encompassing 14 elementary students, represent the educational ability level, racial, and socio-economic diversity of the students in the school. The findings suggest that targeted movement activities showed noteworthy gains in auditory digit span in students who participated in the maze. A review of related literature highlighted the dominance of for-profit movement based interventions targeting students with social, emotional, and learning problems. This study sought to investigate the impact of targeted movement activities on all students in a low-cost, time efficient program that is able to be instituted in an elementary school setting. The study utilized the auditory digit span measurement as a way to assess cognitive function. The findings in this study underscored the importance of targeted movement activities. A teacher interview was employed to gain insight into the implementation of the program and assess insight in program benefits and results. The study concluded by exploring various implications for targeted movement activities in elementary settings.

Table of Contents

List of Tables

# Chapter I: Introduction

*In order to succeed in life, God provided man with two means, education and physical activity. Not separately, one for the soul and the other for the body, but for the two together. With these two means, man can attain perfection. –Plato*

## Introduction to the Problem

Educators are always looking for ways to enhance teaching practices to improve student outcomes. Many new initiatives are regularly implemented in educational settings. There has yet to be discovered one perfect way to teach all children.

Research is helping teachers understand why certain strategies work (Wolfe, 2001). According to a Minnesota Department of Education study, over half of Minnesota five-year-olds are not fully prepared for kindergarten (2013). Many children come to school unprepared to learn, stated Candace Meyer (2009), developer of the Minds-In-Motion Maze program. Meyer proposed that much of a student's unpreparedness for a school setting is related to the development of his or her brain and their brain's capacity for learning. Many students, from all walks of life, have brains that have not been stimulated enough to properly develop necessary functions for school readiness and learning. The focus of child development has moved from complex motor stimulation to a more sedentary lifestyle (Meyer, 2012).

Modern conveniences, technology, and safety measures have vastly altered the development of the human brain (Hannaford, 1995; Jensen, 1998). Many children's brains do not experience important stimulations that aid the brain in proper function. Researchers are discovering that stimulating a child's brain through specific movement activities increases the functioning of the brain, making children more prepared to learn (Berg, 2010; Hannaford, 1995; Jensen, 1998; Meyer, 2005; Vidoni, Lorenz & Terson de Paleville, 2013).

**Background of the Study**

Safety precautions, technological advances, and lifestyle changes are influencing the development of the brain from embryo to death (Jensen, 1998). The brain of a child is often lacking the appropriate stimulation to develop the neural pathways and cognitive functions necessary for success in school. Through experiences in remote African communities, Hannaford (1995) described "an understanding of the critical developmental factors necessary for the elaboration of full learning potential" including the necessity of "lots of movement and the ability to freely explore one's body in space" (p. 209).

Advancements in brain imaging technology have provided researchers with the ability to understand and map cognitive function in response to specific stimuli (Sousa, 2006). The application of brain imaging devices such as Functional Magnetic Resonance Imaging (fMRI) provides increased understanding of the functions of the brain, both challenging some conventional educational beliefs, while necessitating that the information discovered from continuing brain imaging research affect the development of future educational practices (Sousa, 2006; Wolfe, 2001). Educators seek to maximize learners' potential by activating full brain function, and such practices that favor learning should be studied and further cultivated (Hannaford, 1995; Sousa, 2006; Wolfe, 2001).

**Statement of the Problem**

This study worked to address the problem of students who have difficulty executing the daily tasks necessary in a classroom setting. Many students lack proper stimulation of the vestibular system as their brains are developing. This lack of stimulation can lead to difficulty in areas related to cognitive ability and participation in the classroom.

"To improve your thinking skills, *move*" (Medina, 2008, p.28). Research on the brain and learning has continued to demonstrate the strong connections between targeted movements and neural functioning (Berg, 2010; Bert, 2010; Caine & Caine, 1995; Medina, 2008; Ratey, 2008; Rodger, 1996; Templeton & Jensen, 1996; Yongue, 1998). The level of every child's health and wellness can be improved, and the power movement, physical activity and exercise can have on the developing brain is amazing (Lengel & Kuczala, 2010).

**Purpose of the Study**

The purpose of this study was to investigate the effectiveness of the Minds-In-Motion Maze targeted training activities on increasing student cognitive ability in the regular education elementary classroom. Integrative movements have shown promise in stimulating learning and creative, high-level thinking, and these movements increase the capacity of the mind/body system by increasing neural pathways and cross-lateral connections, thus making the learning process immeasurably more effective (Hannaford, 1995).

This study explored the relationship between targeted movement activities and their influence on the brain's functioning. The benefits of targeted movements on specific brain systems were studied to determine which movements were most beneficial for children in improving learning readiness.

This study gathered data in order to build a deeper understanding of the effects of the Minds-In-Motion Maze. A qualitative multi-case study approach was used to assess the implementation of the Minds-In-Motion Maze in one prekindergarten- grade five elementary education combination classroom. The study investigated the effectiveness of the Minds-In-Motion Maze targeted training activities on increasing student cognitive ability measured by auditory digit span, student movement abilities, and teacher observed differences in students in the regular education elementary classroom.

**Rationale**

The increase in cognitive function of brain systems due to the benefits of specific movement activities has been demonstrated by multiple researchers (Berg, 2010; Templeton & Jensen, 2000; Vidoni, Lorenz & Terson de Paleville, 2013). The benefits of targeted movements on specific brain systems needs to be studied by researchers to determine which movements are most beneficial for children in improving learning readiness. Medina (2008) suggested that research is necessary to discover what type of movement should be conducted and how often specific movements should be done to achieve the maximum benefit.

The Minds-In-Motion Maze, developed by Candice Meyer (2012), has been specifically designed to provide intervention to improve or strengthen multiple areas of cognitive brain function and alleviate the problems that correlate to improper function of these brain areas and systems. Neuroscientist and researcher Carla

Hannaford (1995) expressed the need to stimulate the vestibular system and ocular systems, and to increase static and dynamic equilibrium to optimize the function of the brain, readying it for learning. The Minds-In-Motion Maze was developed to increase the functions of these necessary brain systems by using targeted activities to stimulate each area.

**Research Questions**

The three questions explored in this qualitative case study were:

1) What was the effect of the Minds-In-Motion Maze program on capacity for working memory as measured by the Auditory Digital Span assessment?
2) What were the effects of the Minds-In-Motion Maze program on an individual's movement abilities as measured by the Motor Development/Visual Perception Battery of Assessments?
3) What differences were observed by the classroom teacher at the end of the 12-week implementation of the Minds-In-Motion Maze program in the areas of classroom performance, self-control, and social-emotional behaviors?

**Significance of this Study**

More research was needed to discover if the Minds-In-Motion Maze program stimulates the vestibular system, and if this stimulation translates to improvement in necessary learning skills. Hannaford (1995) cited Brain Gym exercises that stimulate the vestibular system. Research conducted by Hyatt (2007), Nussbaum (2010), and Stephenson (2009) has been done in educational and clinical settings on the effectiveness of the Brain Gym program as an overall intervention. These programs did not, however, reveal a specific connection of the Brain Gym activities to the brain system. They also failed to identify the cognitive processing limitation the activity was targeted to improve. This limits the credibility of the intervention, and makes the measurement or understanding of the intervention challenging. The Minds-In-Motion Maze program implements specific stimulation activities and explains how these targeted interventions can improve each specific brain system or cognitive processing limitation.

A gap exists in the literature related to the implementation of targeted movement activities in regular education settings with elementary age students. This study had the potential to make a contribution by exploring if, and how, the Minds-In-Motion Maze program influenced students' working memory measured by auditory digit span. Integrating targeted movement activities into the elementary educational setting is a common sense, drug free alternative that has the potential to increase the function of mind and body systems and greatly facilitate lifelong learning (Hannaford, 1995).

**Definition of Terms**

*Cognitive Development.* Mental increase involving knowledge and the development of intellectual skills (Lengel & Kuczala, 2010)

*Digit Span.* The ability of a person to memorize and recall a series of digits.

*Minds-In-Motion Maze.* A movement based intervention implementing 15 specific stimulation activities aimed at improving specific brain systems and cognitive processing.

*Movement*. Any activity that utilizes the gross motor skills of the body.

*Movement Based Intervention*. A program that involves students doing specific, targeted movements with aim of specific results.

*Vestibular System*. The area of the brain that is important for keeping balance, coordinating the movements of the body, and turning thought into actions.

**Assumptions and Limitations**

The issue of generalizability is citied as a possible limitation of case study research owing to the narrow focus on a single unit for study (Merriam, 2009). Large scale generalizations were not generated from this type of research. However, a case study can reveal much new information that can benefit research in the field, and the vivid descriptions of the case provided by the researcher can create an image that illustrates the situation being studied (Merriam, 2009). The reader of the case study can decide what information can be transferred and applied to their situation (Merriam, 2009).

A second limitation to qualitative, case study research is the integrity and effectiveness of the primary instrument of data collection, the researcher (Merriam, 2009). An unethical case study researcher can describe the data in a way that illustrates something the researcher wishes to show instead of what the data truly reveals (Merriam, 2009). Merriam suggested that there is no greater bias in case study research toward confirming a preconceived hypothesis than in other forms of research. It is paramount that the researcher honestly and accurately reports the findings of the study (Roberts, 2010). The ethics of the investigator influence the validity and reliability of the study (Merriam, 2009). Both the reader and researcher are advised to recognize these potential biases and how they relate to the presentation of findings (Merriam, 2009). It is assumed that the researcher conducted research with honesty and integrity, and classroom teacher observations of behavior based on interview discussion validated the data gathered as a part of the research study.

**Nature of the Study**

The effectiveness of the Minds-In-Motion Maze program was examined in this study of student ability in a regular education elementary classroom. A qualitative multi-case study approach was used to assess the changes students experienced as a result of their participation in the Minds-In-Motion Maze in one regular education, prekindergarten through grade five elementary education classroom combination.

**Organization of the Remainder of the Study**

Organized into five chapters, a bibliography, and appendices, the study begins with an introduction followed by a literature review organized into six areas. The first area explores the structure and functions of the human brain in relation to its link to education and early learning. Next, changes brought about by modern improvements increasing safety and convenience are examined in relation to the influence on the brain. In addition to these changes, a decline in the amount of school time devoted to physical education and movement has, according to some authors, negatively impacted learning. Several targeted movement interventions are discussed, some featuring little to no empirical research support, followed by a focus on the Minds-In-Motion Maze program. The final area reviewed the digit span measurement tool, which has been used to calculate the impact of movement on student learning.

The third chapter details the methodology used to collect the data including the sample, setting, and measures, along with data collection procedures, field testing, and data analysis. Results are provided next. The final chapter contains conclusions and recommendations. A bibliography and appendices bring the study to a close.

# Chapter II: Review of Literature

## Introduction

Educators have repeatedly questioned the connection between the mind and the body. Pioneering research in the mid-1960s by University of California Berkley researcher Marian Diamond revealed that the structure of the brain is modified by the environment (Diamond & Hopson, 1998). Educators can literally alter the biological structure of the brain through activities and targeted interventions (Cameron, 2011; Jensen, 2000; Sousa, 2006; Wolfe, 2001; Wolfe & Brandt, 1998). The specific linkage between movement experience and cognitive development has been cited by multiple researchers (Benelli & Yongue, 1995; Griss, 1994; Hautala, 1996; Lengel & Kuczala, 2010; Parnell, 1996; Rodger, 1996; Sibley & Etnier, 2003; Summerford, 2001; Vidoni, Lorenz & Terson de Paleville, 2013; Yongue, 1998).

A meta-study conducted by Sibley & Etnier (2003) quantitatively combined and examined the results of studies pertaining to physical activity and cognition in children. As a result of their statistical investigation of the literature, the researchers concluded that there is a significant positive relationship between physical activity and cognitive functioning in children. Similar results were noted by Summerford (2001). Her study compared the mental performance of students who were involved in regular continuous activity to that of a group of inactive students and found that the physically active students performed significantly better on mathematics tests. The physical movements that a person participates in can directly influence the way a person thinks, learns, and remembers (Lengel & Kuczala, 2010; Ratey, 2008).

A systematic review of 14 previous studies, 12 in the United States, one from Canada, and one from South Africa, conducted by Vrije Medical Center in Amsterdam (Singh , Uijtdewilligen, Twisk, van Mechelen, & Chinapaw, 2012) cited strong evidence of a significant positive relationship between physical activity and academic performance in children.

The way and the extent to which movement influences the development and function of the brain are in the early stages of research. Research (Vives-Rodriguez, 2005; Vidoni, Lorenz & Terson de Paleville, 2013) has been conducted in the area of movement in early childhood education. The importance of targeted movement education programs in preschool age children have been documented, but little attention has been given to elementary age students. The impact of movement programs on students with disabilities has also been studied at length revealing multiple benefits of targeted movements in these particular students (Cameron, 2011; Galaburda, 2005; Sweet, 2010; Wiithro, 2007; Zambo, 2011). A gap exists in the research related to movement based interventions implemented with regular education, elementary age students.

There is a window of opportunity in children, between birth and age 10, where the number of synaptic connections in the brain increases rapidly, and then begins to decline (Wolfe & Brandt, 1998). Fifty percent of the ability to learn is developed in the first four years of life, and another 30% before age eight (Dryden & Vos, 1999). This does not mean that 50% of a person's wisdom or knowledge is obtained by age four, it means that in the early years a child forms the main pathways for learning in the brain and everything else is built on that base and grows from that core (Dryden &

Vos, 1999). Early educators need to capitalize on this window of rapid brain development to build a solid foundation for lifelong learning.

**Brain Basics**

It does not make sense to design instruction to change the very formation of the human brain without understanding the brain and how it functions (Wolfe, 2001). Learning and rehearsing complex movement sequences stimulates the prefrontal cortex, which is the area of the brain used in learning and problem solving; this stimulation can improve the student's capacity for learning (Hannaford, 1995; Lengel & Kuczala, 2010). To better understand how stimulation of the brain can improve the capacity for learning, the brain must be examined.

The human brain weighs about three pounds, is made up of 78% water, 10% fat, and eight percent protein, and consists of 40 or so major structures (Jensen, 1998; Wolfe, 2001). The brain is divided into various areas that are responsible for specific functions, though areas of the brain work together to perform many tasks. Sousa (2006) provided a tour of the brain starting with the largest part of the brain, the cerebrum. The cerebrum is divided into hemispheres with each hemisphere divided again into sections called lobes.

Each lobe of the cerebrum is responsible for different processes. The frontal lobe is responsible for conscious thinking, speaking, and planning. This area of the brain matures slowly throughout adolescence into early adulthood, resulting in children and adolescents being more likely to submit to their emotions. The frontal lobe also controls conscious body movements and coordination. This area controls the muscles of the face, hands, tongue, legs, and many other body parts. The temporal lobe receives signals translated by the ears and nose and interprets them as sounds and smells. Above the temporal lobe is the parietal lobe, the area of the brain that interprets sensations such as pain, pressure, touch, and temperature. After a sensation is interpreted by the parietal lobe, it sends a message to the frontal lobe. The frontal lobe then gives the command to the part of the body affected by the sensation, telling that area of the body what action to take. The occipital lobe is the section of the brain that interprets messages from the eyes.

Two major divisions of the brain, the cerebellum and the brain stem, operate at a subconscious level, managing such functions as respiration, balance, and heartbeat, in addition to automatic controls of body movement, eyesight, and hearing. The window of opportunity for motor development appears to be most pronounced during the first eight years of a child's life. The brain's plasticity allows for change and growth throughout life, but the critical periods identified for specific brain development represent times when the brain demands stimulation in order to create or stabilize long-lasting structures, making these times of practice or teaching most effective (Healey, 2004; Sous, 2006). Tasks such as crawling and walking require complicated associations of neural networks including integrating information from balance sensors in the vestibular system and output signals to leg and arm muscles (Sousa, 2006).

Educators have a tendency to focus attention and research on the prefrontal cortex due to the fact that it is the area where information is synthesized and the highest forms of mental activity take place (Wolfe, 2001). However, focusing only on this area of the brain is not wise. "Many parts of the brain must work together in a complex set of interactions for us to engage in a seemingly simple act," (Wolfe, 2001, p. 42-43). Many sections of the brain play critical roles when people construct and recall memories and process information, and almost all of these structures operate outside conscious awareness (Wolfe, 2001).

Scientists identify another intricate component of the brain as the mid-brain. This section includes the hippocampus, thalamus, hypothalamus, and amygdala that "is responsible for many additional functions including emotions, sleep, attention, body regulation, hormones, sexuality, smell, and production of most of the brain's chemicals" (Jensen, 1998, p. 9).

The organs of balance in the vestibular area of the brain are another important system located in this mid-brain region (Wolfe, 2001). In the vestibular system, the inner ear's semicircular canals and the vestibular nuclei provide the information gathering and feedback source necessary for bodily movements (Jensen, 1998).

> The vestibular system gets its raw information from the vestibular organs, which consist of three semicircular canals and the otolith organ. The three semicircular canals are oriented along the x, y, and z axes, and define motion on each of the three dimensions of space. When the head moves, hair cells detect the motion of the fluids inside each canal. The brain uses this information to calculate changes in inertia, in much the same way that the inertial navigation system on an airliner senses changes in position and velocity. The otolith organ uses a pendulum-like appendage, the utricle, to orient the sense to the vertical force of gravity. (Belgau, 2004, p. 5)

This area of the brain is important for keeping balance, coordinating the movements of the body, and turning thought into actions (Jensen, 1998).

The motor system and other brain systems that are responsible for gross and fine motor skills, and the auditory and visual systems, are built on, integrated with, and highly dependent upon the frequent inertial and gravitational underpinnings provided by the vestibular system (Belgau, 2004). Belgau went on to say, "The individual's ability to balance [coordinated by the vestibular system] is indicative of the efficiency of his or her brain processes" (p. 4). Due to the significance of dynamic balance and the vestibular system, Jensen (1998) stressed the importance of playground games that involve swinging, rolling, and jumping because of the inner ear stimulation that occurs during such activities. "Movement, particularly stimulation by rocking, spinning, or hanging upside down, helps develop a large and important area behind the brain stem: the cerebellum, which connects the vestibular system that is linked to the balance mechanisms in the inner ear" (Healey, 2004, p. 23). Activities that require students to manipulate their bodies in positions that get them upside-down and backwards help stimulate the vestibular system.

Maintaining balance while moving is less demanding than while holding still, so student with an underdeveloped vestibular system seek out movement (Green, 2006). An illustration on this occurrence would be a student rocking in their seat or spinning in circles attempting to wake up a sluggish vestibular system (Green, 2006).

The brain's sense of proprioception works to constantly engage the position of the body based on the information it receives from the senses. This important sense is described by Belgau (2004) as the awareness of the position and movement of the body in space. The brain must properly integrate sensory stimuli from tactile senses relating to touch and pressure, vision, body position, and the vestibular system to engage in effective proprioceptive processing.

The outer part of the brain is covered in convolutions, or folds, that are part of the cerebral cortex (Swedlund, 2003). Wolfe (2001) provided many important insights into how this area of the brain functions. She described the cerebral cortex as covering the cerebrum and consisting of two hemispheres that are connected by bundles of nerve fibers. The connecting fibers allow the two hemispheres of the brain to exchange information freely. These are known as the right and left hemispheres of the brain, and their functions and interactions are strongly debated. Wolfe's research stressed that although each hemisphere has its specialty, both sides of the cerebral cortex must work together at all times to produce a single view of the world. This teamwork only occurs when the neurons in the brain communicate with each other. The connecting neurons accomplish this collaboration with both chemical and electrical signals.

Wolfe (2001) further explained that the cerebral cortex is the portion of the brain that receives attention from educators because this area allows humans to operate at a conscious level to express feelings and have an awareness of who they are and what they are doing. All areas of the brain must function together for body systems to operate effectively since the brain and body are inextricably linked. If a specific area of the brain or system in the body is not functioning properly, the rest of the brain and body will suffer as a result of this dysfunction. Learning in an educational setting becomes more difficult if all areas of the brain and body are not functioning properly, and then the brain needs to work harder to compensate for this inefficiency (Meyer, 2012).  Each part of the brain is important, and the necessity to work together means no structure of the brain can perform at its best working alone.

Wolfe (2001) suggested that educators need to understand how the brain functions and appreciate the implications this knowledge has on educating students. The implementation of strategies that increase brain function and utilize the mind-body connection may improve student learning and educational outcomes. Information about how the brain works is an essential element to consider when making educational decisions; "the better we understand the brain, the better we'll be able to educate it" (Wolfe, 2001, p. vi).

**The Changing Brain**

Many of the modern conveniences and safety measures that have been implemented, due to liability issues, and an increased use of technology, have vastly altered the development of the human brain (Hannaford, 1995; Healy, 2004; Jensen, 1998).  Sousa (2006) referenced the changing brain acknowledging that the brain of students today is vastly different from the brain of students a few years ago.  Healey (1990) cited the fast-paced visual stimuli that children experienced further led to the unpreparedness for academic learning.  The little red wagon is an example of attempting to make something safer for children, but one outcome is removing valuable stimulation that arouses the brain and better prepares it for learning.  Many wagons now come with backrests, seatbelts, and stable tires.  A child can ride in the wagon in complete comfort and safety; however, valuable developmental processes are taken away from the child.  The "old-fashioned" wagon ride provided a child with many opportunities to develop important body systems. As the wagon hit a bump in the sidewalk, the child had to adjust their body to maintain balance. The child's vestibular system was stimulated and needed to react to stabilize the upright position of the body. Important neck muscles were strengthened and these muscles govern attention and coordination (Meyer, 2005).

Inventions designed to keep children safe are discouraging necessary developmental experiences. In removing apparatuses from playgrounds, like merry-go-rounds for example, children are missing the stimulation their brains need to function at optimal levels (Hannaford, 1995; Jensen, 1998). Educators frequently see lack of school readiness in students from all perspectives and socioeconomic classes (Jensen, 1998). Educators search for methods to enhance brain activity since a better functioning brain makes learning easier and more efficient.

Research has revealed that brain derived neurotrophic factor (BDNF), an important chemical Ratey called "Miracle-Gro" for the brain, is produced in greater amounts by the brain as a result of exercise (Ratey, 2008; Viadero, 2008). BDNF encourages brain cells to sprout synapses that are necessary for it to learn and grow, and to strengthen cells and keep them from dying (Lengel & Kuczala, 2010; Ratey, 2008; Viadero, 2008). BDNF is an essential chemical for optimal brain health and learning preparedness.

**Reduction in the Value of Movement in Education**

School administrators play a key role in encouraging teachers to implement planned movement activities (Vidoni, Lorenz & Terson de Paleville, 2013). The hyper-focus on high-stakes testing has caused educational settings to place less value on student movement and instruction built around this developmental need. Many school administrators view time devoted to physical education as time taken away from instruction in academic subjects (Shephard, 1997), and recess and break times have been shortened or eliminated from student schedules (Walker, 2009). The study by Walker also stated that a positive connection was found indicating that free play at recess enhanced learning. Recess and movement activities have been interpreted by some as taking away from more productive uses of time, but multiple researchers (Benelli & Yongue, 1995; Berg, 2010; Caine & Caine, 1995; Hautala, 1996; Jensen, 2000; Rodger, 1996; Vidoni, Lorenz & Terson de Paleville, 2013; Yongue, 1998) have shown that this is an incorrect assumption. Medina (2008), the director of the Brain Center for Applied Learning Research, described the powerful cognitive effects of physical activity, noting that it does not make sense to take it out of a school day in an attempt to produce higher functioning students. Free play, recess, and structured movement instruction are necessary for developing high-functioning, well-integrated students (Lengel & Kuczala, 2010).

Though a necessary element in student development, free play periods are not a substitute for structured movement experiences designed to assist children in developing physical skills (Sanders, 2002; Vidoni, Lorenz, & Terson de Paleville, 2013). Research by Manross (2000) has shown that young children do not automatically develop physical skills simply through play; they must be taught. His study encompassed 360 fourth and fifth grade students at two elementary schools and assessed their acquisition of throwing skills. A study of 18 preschoolers in an Alabama daycare (Wadsworth, Robinson, Bekham, & Webster, 2012) found that planned physical activities were necessary to develop gross motor skills, and classroom teachers needed to understand the importance of daily structured physical activity for children during the school day. Structured movement instruction is a necessary element in education, and must become an honorable part of the required curriculum (Jensen, 1998).

A study at Naperville Central High School near Chicago, Illinois, investigated student participation in an intensive fitness program targeted at increasing heart rate to an aerobic level. Students engaged in aerobic activity before the school day begun, and the students' most academically rigorous classes were scheduled immediately after the aerobic activity. Ratey (2008) described various test scores at Naperville school as being significantly higher than other schools in the area and the state of Illinois, and he determined that this "correlation is simply too intriguing to dismiss" (p. 15). Naperville had placed an emphasis on a physical education program that increased physical fitness in its students, and the school has realized benefits in the overall health of students along with high test scores following implementation of the program.

A study conducted by the California Department of Education compared students' fitness levels, recorded by the FitnessGram that measures six areas of fitness, with standard achievement test scores for more than one million students. The study found that students measured as "fit" according to outcomes in all six areas measured by the assessment tool scored twice as well on academic tests than their "unfit" peers (Grissom, 2005). A panel of noted researchers in fields from kinesiology to pediatrics conducted a massive review of 850 studies related to physical activity and school-aged children, and concluded that physical activity is a necessary part of a student's day (Janssen & LeBlanc, 2010).

Animal studies are used to increase understanding of how the brain functions (Wolfe, 2001). One study of rats in complex versus impoverished environments showed a 20-25% greater number of synapses per nerve cell in the rats that spent time in the complex environment (Bransford et al., 2000). Another study required groups of rats to do four different things. One set of rats performed exercise 60 minutes a day, another had the opportunity to exercise when they wanted, a third did not do anything, and the last group of rats was taught to traverse an elevated obstacle course. The rat groups that participated in exercise showed a higher density of blood vessels in the brain, but the "acrobats" that learned to navigate the obstacle course stood out by demonstrating a significant increase in the number of synapses per nerve cell. The study concluded that learning through the obstacle course added synapses while exercise alone did not. Diamond's work stressed the need for a novel environment that presents appropriate challenges for children to thrive (Diamond & Hopson, 1998).

Grissmer, Grimm, Aiyer, Murrah, and Steele (2010) suggested that motor and cognitive development were complexly and inextricably linked citing that some of the neural infrastructure linking the prefrontal and motor areas of the brain are used to control development in both areas.

Haapala et al. (2013) conducted a study of 174 Finnish children in grades 1 and 2 and 167 children in grade 3. Children who performed poorly in agility, speed, and manual dexterity tests which resulted in poor overall motor performance in the first grade had lower reading and arithmetic test scores in grades 1 through 3 than children with better performance in the same motor tests.  These associations were stronger in boys than girls.  Researchers found cardiovascular fitness was not as strongly related to academic skills.  The findings in this study highlighted the importance of motor performance and movement skills over cardiovascular fitness for children's school success during the first years of school. The researchers suggested academic development of children with poor motor performance should be carefully monitored and appropriate actions to support the development of reading, arithmetic, and movement skills should be started when needed.

A cross-sectional study conducted with 2,038 Spanish children and adolescents, ages 6-18 years of age found that cardiorespiratory capacity and motor ability, both independently and combined, were related to academic performance. This study found motor ability may be more important for academic performance, because the association of academic performance and physical fitness was stronger for motor ability than cardiorespiratory capacity. In contrast, children and adolescents had lower grades when they had both lower levels of motor ability and cardiorespiratory capacity.  Researchers in this study linked motor ability to cognition and believed physical activity programs that included motor training may improve motor ability as well as academic performance.  One explanation cited by the researchers that might partially account for the greater association of motor ability with academic performance was the mental processing involved in motor ability. Motor tasks that represent different challenges to the participant may lead to more improvement in academic performance (Esteban-Cornejo et al., 2014).

## Brain Gym

"Sensory integration activities that require individuals to balance precisely and make spatial judgments…are the most powerful and effective activities available for maintaining and improving brain-processing efficiency and allowing an individual to become an efficient learner and improve academic success" (Belgau, 2004, p. 4). Several programs have been created in an effort to help connect targeted movement activities to an increase in an individual's capacity for learning.

Research conducted by Hyatt (2007), Nussbaum (2010), and Stephenson (2009) in educational and clinical settings focused on a program developed by Paul Dennison in the 1980s called Brain Gym. Brain Gym is "a unique program of physical activities that synchronizes body and mind to enhance learning and achievement for people of all ages and abilities" (Brain Gym International, 2011, p. 1). Brain Gym includes simple, quick, and task-specific movements designed to benefit the functioning of anyone who utilizes the techniques (Hannaford, 1996; Templeton, 1996). The research sought to support the improvement in overall cognitive function in students after implementation of the targeted movements outlined in Brain Gym (Hyatt, 2007; Nussbaum, 2010; Stephenson, 2009). Brain Gym activities are designed to specifically develop and stimulate the vestibular system, promote balance, improve core strength, and increase cross-lateral neural connections between brain hemispheres (Hannaford, 1996; Nussbaum, 2010).

The targeted activities of Brain Gym have resulted in vast improvement in students with specific special needs such as ADD, ADHD, and multiple learning disabilities (Hannaford, 1996; Stephenson, 2009). The measures used to test the effectiveness of the program on regular education classroom settings have shown mixed results (Hyatt, 2007; Nussbaum, 2010).

Many of the tools used to measure the results of these studies were not the proper instrument to appropriately calculate the positive effectiveness of Brain Gym (Muijs, 2011). Hannaford (1996) found that Dennison's Brain Gym program produced increased physical and cognitive function in subjects of all ages, across cultures, and related to multiple cognitive limitations. Research by Hyatt (2007), Nussbaum (2010), and Stephenson (2009) has been done in educational and clinical settings on the effectiveness of the Brain Gym program as an overall intervention. However the specific connection of the Brain Gym activities to the brain system or cognitive processing limitation(s) the activity is targeted to improve is not specified. This lack of connection limits the credibility of this intervention, and makes the measurement of positive change from the intervention more challenging. Brain Gym International states that its philosophy is based on empirical experience rather than neurological research and cites testimonials as the main basis for the success of the program (Brain Gym International, 2011). Without the capacity to define and measure results of the program, Brain Gym has declined in popularity.

**Other Targeted Movement Interventions**

Many other movement programs have been developed aimed at improving student cognitive function; however there appears to be little empirical research in a school setting to verify the program efficacy. The developers rely on observations of teachers and administrators who successfully use these programs. They often cite multifaceted success among students who have used their specific programs.

Some researchers have worked to build upon the fundamentals established by Brain Gym. Koester (2006) developed Movement Based Learning, an activity-based program that builds on the Brain Gym fundamentals so that children with special needs can learn how to learn (Koester, 2006). Her program uses Brain Gym activities with special education students. The emphasis of Koester's program uses basic developmental movement patterns to enhance the neurological function of each student to help them reach their greatest potential.

Bal-A-Vis-X, another movement-based program, was developed by Bill Hubert in 2001. It consists of a series of some 300 exercises, most of which are done with sand-filled bags and/or racquetballs, often while standing on a Bal-A-Vis-X balance board (retrieved from www. Bal-A-Vis-X.org). These exercises include many mid-line crosses and visual tracking, and progress to more difficult levels as the participant increases in proficiency. The Bal-A-Vis-X balance board was designed to adjust to increase the challenge and potential stimulation of an exercise done on the board.

Yet another movement based program is The Action Based Learning Lab, comprised of a series of stations designed to prepare the brain for input and processing. Sensory components of balance, coordination, spatial awareness, directionality, and visual literacy are developed as the child rolls, creeps, crawls, spins, twirls, bounces, balances, walks, jumps, juggles, and supports his/her own weight in space (Blaydes & Hess, 2004). Developed by Jean Blaydes Madigan and Cindy Hess (2004), it stressed proper development and remediation of the vestibular system through targeted movement activities. An elementary school in Pennsylvania that used the lab has only four students out of 220 in the kindergarten through second grade who were not reading on grade level compared to the norm of 12 to 15 (Lengel & Kuczala, 2010). Observation and data collection at many schools that implement the Action Based Learning Lab program showed positive results. Qualitative data, such as one principal's comment, pointed to observations of being more alert, interactive, and responsive following the morning exercises involved in the program.

Brain Highways Alphabet developed (Green 2006) to teach young children letters. It incorporated specific, targeted movement activities during each lesson on learning to identify, say, and write the letters. Green developed the lessons so that students' basic brain-processing needs for vestibular movement were met during the lesson so they could stay focused and attentive on the content.

Since the 1960s Belgau has continued to develop a system called The Learning Breakthrough Program based on NASA research of astronauts who had returned from space and suffered the effects of zero gravity. The program included balance as the central component, multi-sensory integration, spatial awareness, integration between the two hemispheres of the brain, brain timing/reaction time, varying the difficulty level of activities, sequencing, binocular teaming, and proprioception. The Learning Breakthrough Program works to develop and refine the basic brain organizations that are the foundation of all learning (Belgau, 2004).

The DORE exercise program was initiated by businessman Wynford Dore to help his daughter Susie who was diagnosed with dyslexia. The program included balance, sensory, visual/motor, and gross motor skill exercises performed twice daily at home (DORE, 2014). DORE centers opened to serve children but were extremely expensive. They have since closed in the United States, though they continue to operate in the United Kingdom.

Brain Balance was developed by Dr. Robert Melillo in the 1990s to help correct disorders such as dyslexia, attention deficit disorder, and cognitive processing difficulties in a drug-free way. The program integrated three areas of brain development: sensory motor exercises, cognitive activities, and nutritional guidance in an attempt to address the root cause of most learning and developmental issues. The sensory motor activities in Brain Balance include movements targeting muscle tone, strength, and coordination, rhythm and timing, bilateral coordination, dominance, gross and fine-motor skills, primitive and postural reflexes, eye-muscle balance and coordination, and vestibular balance and posture (Brain Balance, 2014). The program is implemented at franchised centers around the country. As with these other vender-based movement programs, the author's findings signify the value of the program without empirical, research-based support.

There are also several versions of movement-related classroom interventions in the United States that incorporate some important movement concepts. These include but are not limited to S.M.A.R.T. (Stimulating Maturity through Accelerated Readiness Training) curriculum and Energizers for the classroom. There are also similar programs in many countries across the globe. These programs seek to get to the root of many students' problems through specific movement activities that target the physiological source of the learning difficulty. Like the programs mentioned previously, most are created as for-profit enterprises, and lack support of empirical research. Due to the cost, many children are not being reached with these movement-based interventions. The Minds-In-Motion Maze program sought to make targeted movement activities accessible to all students. It also is substantiated with quantitative empirical research done on a population of preschool students at the University of Louisville by Vidoni, et al. (2013).

**Minds-In-Motion**

The Minds-In-Motion program extends beyond the activities of Brain Gym and other movement programs while focusing on vestibular stimulation. Seeking to improve the function of multiple body systems, the Minds-In-Motion program has been developed to integrate the two hemispheres of the brain, improve neural integration through movements that focus on balance, and increase eye-hand coordination (Meyer, 2005). The Minds-In-Motion program self-proclaims the use of cutting-edge technology at its centers to address the neural integration and vestibular deficit concerns. The Minds-In-Motion Maze intervention has combined 15 movement activities targeted to address multiple body systems into a “maze” designed to engage students in specific movements that can be set up in any school.

Cross-lateral movements improve nerve connections and communications between the cerebral hemispheres of the brain and facilitate learning throughout life (Hannaford, 1997; Jensen, 1998). Crossing the midline of the body, an imaginary line that runs through the body from the head to the toes, is one focus of the Minds-In-Motion Maze and several of the other movement interventions. The neural pathways used to move the arm or leg in a cross-lateral movement exercise engages many of the same neural pathways used in educational experiences, and these movements increase the integration of the brain (Hannaford, 1997, Wolfe, 2001).

Wolfe (2001) explained that dominance of one side of the brain is natural, but use of only one side of the brain is insufficient for cognitive function. The integration of the two hemispheres is essential to optimal brain function, and therefore enhanced learning. Research shows that both sides of the cerebral cortex must work together at all times to produce a single view of the world.

The vestibular system regulates equilibrium and sensations, and wakes up the brain so it can absorb new information (Hannaford, 1995; Jensen, 1998). The vestibular system is centrally connected to multiple brain systems, and it is critical to the attention system because it regulates incoming sensory data (Jensen, 1998). The vestibular system plays an important role in school readiness, and lack of stimulation for this important body system is linked by researchers to many learning deficiencies (Lengel & Kuczala, 2010).

The Minds-In-Motion Maze includes large-motor activities that stimulate this important system. The fluid in the vestibular system can become congealed without regular stimulation. When congelation takes place, the system does not function properly, creating miscommunications between brain systems (Meyer, 2012). Spinning, rocking, and twirling are vestibular activation motions that lead to alertness, attention, and relaxation in a classroom setting (Hannaford, 1995; Jensen, 1998). A student with an underdeveloped vestibular system will often pursue movement to remain in balance (Green, 2006). Students will seek to engage in stimulating activities spontaneously, but are reprimanded because the movements appear to the teacher as a lack of attention. The student is striving to gain or regain attention with these movements, but misunderstanding leads many teachers to squelch this type of activity (Jensen, 1998).

Inclusion of vestibular stimulation activities in school could be beneficial for all students (Hannaford, 1995). The Minds-In-Motion Maze includes several movements that were designed to specifically target the vestibular system by moving the body upside down, sideways, and backwards. The "Jelly Roll" involves students rolling on a mat on the floor in a predetermined way. The "Balance Board Bash," where students stand on a balance board, stimulates the vestibular system and focuses on balance. The addition of a rebounder, or mini tramp, to the maze would provide additional stimulation to the vestibular system. Many Maze activities incorporate some vestibular stimulation with an additional focus on balance. These specific movements include "Monster Mash" where students stomp down hard on shapes laid on the floor in patterns, "Climb Every Mountain" where students step over hurdles or obstacles of varying height, "Jumping Jack Flash" where students do a standing broad jump, "Cross Walk" where students raise and touch the opposite knee while walking, "The Beam Team" where students walk in various ways on a balance beam, and "Skip to My Lou" where students skip with high raised knees (Meyer, 2012, p. 9-23).

The Maze also contains some activities that provide stimulation for the eyes. The visual system is linked to the vestibular system and both work together to control eye movements and the eye's ability to track things such as written words on a page (Lengel & Kuczala, 2010). The "Bean Bag Boogie" is where students throw a bean bag in the air and catch it in various ways, "Eye to Eye" where students track a moving pencil topper with their eyes, and "Eye Can Converge" where students focus on each bead on a string (Meyer, 2012, p. 9-23). The string used for “Eye Can Converge” is similar to a Brock string used by vision therapists. As the weeks progress each activity varies to provide the novelty the brain needs to stay engaged and continue to create new neural pathways, a concept stressed by Diamond (Diamond & Hopson, 1998).

In association with the University of Louisville, Vidoni, et al. (2013) conducted a study of 33 preschoolers to assess the effectiveness of implementing the Minds-In-Motion Maze in the preschool setting. The study was based on a 30 minute daily physical activity intervention lasting 11 weeks. It combined Minds-In-Motion Maze activities and stations with additional focused movements targeting the same principles to expand the number of stations in the maze and include additional movements. At the start of each week, incremental changes and additional challenges were added to the daily program and instructions were given to students as they participated in each activity. In addition to the experimental group who received the structured movement time each day, the study utilized a control group that participated in unstructured physical activities either in the classroom or on the playground.

In this study, both the experimental and control groups were pre- and post-tested using the Bruinicks-Oseretsky Test of Motor Proficiency second edition (BOT-2) designed to test fine and gross motor skills. Scaled scores from the BOT-2 assessments were summarized and the number of subjects showing improvement was calculated and empirically compared. The initial assessment revealed both groups were homogeneous in levels of motor proficiency. Following the intervention, the coordination and balance improvements that were observed in the experimental group were significantly greater than what was observed in the control group. The researchers suggested that consistent engagement in the intervention activities resulted in improvement in gross motor skills that would not develop naturally with growth and maturation in an 11 week time period, and that structured movement time played a critical role in development of these skills. Vidoni, et al. (2013) demonstrated that the Minds-In-Motion Maze intervention "resulted in significant changes in preschoolers' motor skills, specifically in balance and coordination" (p. 7).

The Minds-In-Motion Maze has been incorporated into the daily activity of students at over 100 schools in Indiana, Ohio, Kentucky, and Illinois. One elementary principal stated that student use of the program resulted in improved self-control, better handwriting, increased fluency in reading and writing, better organization, increased self-esteem, and less behavior problems. This principal also credited the Minds-In-Motion Maze for the incredible organization and self-control that the students had as a whole when participating in large group activities (Meyer, 2012).

The developer of Minds-In-Motion collected data on over 1,300 students in two centers using the Digit Span Assessment tool and Minds-In-Motion Battery of Movement abilities developed by Minds-In-Motion, Inc. The comparative clinical data showed that when students "have the opportunity to build strong neurological foundations by activating sensory-motor integration processes, they become positioned to learn with ease and success, and are able to reach a higher potential" (Meyer, 2012, p. 73).

Matthew Sabin, a researcher at Eastern Kentucky University, analyzed data of 38 students who participated in the Minds-In-Motion center program. The study included students who were brought by parents to attend programs at the two Minds-In-Motion centers. It was important to note this was a parent initiated intervention in a clinical setting rather than a program embedded into the educational foundation in a school setting. Sabin (2013) noted significant change in pre- and post-assessments in the area of auditory digit span. He found that increase in measures related to balance and motor control had an impact on improvement in sensory processing scores measured by auditory digit span and the Star Reading Test. The Star Reading Test is a tool developed by Renaissance Learning used in K12 schools to assess 46 reading skills in 11 domains.

**Digit Span**

Digit span measures a person's ability to memorize and recall a series of digits. This verbal working memory is involved in numerous daily tasks such as remembering a phone number or reading a long, complex sentence. Individuals must be able to remember the beginning of the sentence by the time they get to the end of the sentence to create meaning from the entire sentence. Verbal working memory is thought to be an element of intelligence, and a digit span test is a common component in many IQ tests, including the widely used WAIS (Wechsler Adult Intelligence Scales). Digit span is part of the working memory index which is a subset of the verbal IQ portion of the assessment. It is one of the dozen components that make up the full scale IQ test (McKeon, 2015).

A research study by Esters (2002) in conjunction with the National Academy for Child Development (NACD), employed drill and practice exercises targeted to help school children in Louisiana increase their digit span. Test scores increased significantly during the eight-month implementation period. No remedial work was done with these students yet they improved far beyond normal expectations. This finding suggested that an increase in the working memory of the brain measured by digit span corresponds to an increase in the function of the brain on many other levels. Digit span has been shown to provide researchers with knowledge of a child's short-term memory and the actual quantity of information a child takes in (Doman, 1986; La Pointe & Engle, 1990). McKoen (2015) stressed the positive correlation between working memory measured by digit span and general intelligence. The subject of a digit span assessment must receive information, process the information, recall and sequence the numbers, and then verbalize the reply. Based on this research, an increase in the brain's digit span capacity can correlate to an increase in brain functionality.

It has been suggested by Doman (1986) that a child should have a digit span that correlates to their age in years up until the age seven, at which point they reach the average digit span for everyone seven years old and above. Another study suggested that children do not reach a seven digit capacity until they reach the mental age of 15, and they increase the number of digits they can remember by one digit every two years until this point (Wolfe, 2001). There is no limit to the digit span a person can develop; spans of 10-15 have been recorded (Doman, 1986). Doman stressed the fact that how well we learn is directly linked to how well we receive, process, and use information acquired from the environment.

Wolfe (2001) recommended caution "in determining the capacity of working memory from tests of digit or word span alone" (p. 98). Working memory is only one small part of overall brain function. Cognitive activities and learning contain continual interplay of processing and storage systems (Wolfe, 2001). Measuring a person's digit span provides one way to gain a glimpse of the cognitive function relating to working memory.

**Chapter Summary**

"Information about the brain and how it learns is not merely interesting, it's an essential element in the foundation on which we should base our educational decisions" (Wolfe, 2001, p.191). No structure of the brain works alone; each area relies on the help of other areas to function properly to construct intricate human thoughts and actions. Stimulating the vestibular system and increasing connections between the hemispheres of the cerebral cortex help aid the overall function of the brain, increasing the function of the overall human system. The focus of education needs to be on building the best student possible, and the connection between early physiological development and the more complex cognitive abilities of students is at the forefront (Meyer, 2012).

The literature review examined the structure and function of the brain, explored various movement interventions, and discussed the digit span measurement tool. It also explored various targeted movement interventions. While some of the interventions included research-based support, others relied on author or teacher verification of its value. The literature review revealed a gap in the literature related to the implementation of targeted movement activities in regular education settings with elementary age students.  Chapter 3 outlines the methodology used to study a specific targeted movement intervention with students in an elementary classroom setting.

# Chapter III: Methodology

## Philosophy and Justification

The study assessed the implementation of the Minds-In-Motion Maze in an elementary classroom setting. The research explored the effectiveness of this program as an intervention that could benefit all students in measurable ways including increased digit span and observational improvements.

The study sought to add to the growing body of literature and knowledge related to the brain-body connection. This section includes the research questions that guided this study, the objective, and a discussion of all research elements including the setting, the sample, and the instruments that were used to gather data. This section ends with ethical considerations related to this study.

## Research Questions

The purpose of this study was to investigate the effectiveness of the Minds-in-Motion Maze targeted training activities on increasing student movement abilities and digit span in the regular education elementary classroom. There was a gap in the literature related to the implementation of targeted movement activities in regular education settings with elementary age students. The study sought to answer the questions:

1) What was the effect of the Minds-In-Motion Maze program on capacity for working memory as measured by the Auditory Digital Span assessment?
2) What were the effects of the Minds-In-Motion Maze program on an individual's movement abilities as measured by the Motor Development/Visual Perception Battery of Assessments?

3) What differences were observed by the classroom teacher at the end of the 12-week implementation of the Minds-In-Motion Maze program in the areas of classroom performance, self-control, and social-emotional behaviors?

**Theoretical Framework**

The focus of education is on building the best student possible. The connection between early physiological development and complex cognitive abilities of students is at the forefront (Meyer, 2012). Seeking to improve the function of multiple body systems, the Minds-In-Motion program has been developed to integrate the two hemispheres of the brain, improve neural integration through movements that focus on balance, and increase eye-hand coordination (Meyer, 2005). The Minds-In-Motion Maze intervention has combined 15 movement activities targeted to address multiple body systems into a "maze" designed to engage students in specific movements that can be set up in any school.

**Research Design Strategy**

A qualitative multi-case study approach was used to assess the changes students experience as a result of their participation in the Minds-In-Motion Maze in one prekindergarten through grade five elementary education classroom combination. This approach provided the structure to render the significance of the situation and seek meaningful information about the implementation of the intervention (Creswell, 2009).

**Measures**

To measure a change in cognitive function, this study administered a pre- and post-assessment to assess students' digit span, and any change in this ability after the intervention. Minds-In-Motion Inc. has adapted protocols developed by Doman (1986) that have been customized into a short oral assessment administered and calculated to give the student an Auditory Digit Span Assessment score.

The Minds-In-Motion Auditory Digit Span Assessment (Appendix A) is a short oral assessment requiring students to repeat back a series of digits starting with two-digit sets working up to their highest level of competency. The test administrator then assigns the student a score based on how many sets are answered correctly. This test has the ability to be administered with no cost and minimal training. Tests were administrated by the researcher to maintain consistency in interpretation of test implementation.

Minds-In-Motion had administered this test to countless clients who have participated in their programs. The test had proved reliable in assessing the digit span of an individual (Meyer, 2012). The validity of the Minds-In-Motion assessment was established by Doman (1986) as he developed his evaluations of auditory and visual digit span.

The Wechsler Intelligence Scale for Children (WISC), developed to test the overall intelligence of individuals, includes a section of the test assessing digit span. The digit span portion of the test is administered in the same way as Doman's test. The overall test has been shown to be reliable and valid. Jensen (1976) assessed the WISC for validity related to multiple ethnic groups and gender. He found the test items to be heterogeneous and the difficulty to be not appreciably different for whites and blacks. The Compendium of Neuropsychological Tests states the substantial correlation of about .5-.8 between the Weschsler IQ's overall battery of tests and other measures of intelligence (Spreen & Strauss, 1991). Digit span alone does not constitute an IQ test, but it works to measure one facet of cognition.

The WISC is expensive, time-consuming, and requires extensive training of the administrator. These constraints made the assessment impractical for use in this study. The Auditory Digit Span Assessment developed by Minds-In-Motion meets the protocols established by Doman and the WISC assessment presented in a practical format.

The Motor Development/Visual Perception Battery of Assessments developed by Minds-In-Motion, Inc. was also be used to collect observational data before and after the intervention (Appendix B). This collection of assessments was used to organize observations of students' abilities in motor and visual competencies. The tool provided a structured protocol for gathering and recording data for analysis.

**Sampling Design**

The implementation of this qualitative multi-case research study of the Minds-In-Motion Maze took place in a regular education, prekindergarten through grade five combined elementary classroom, with students of various ability levels, comprising a total population of 27 students located in a small private school in the Midwest. Students were divided into two groups consisting of prekindergarten-first grade and second-fifth grade in the morning, and a combination of prekindergarten-fifth grade all together in the afternoon as was the structure of the school. The students to be studied emerged naturally through initial observations. Some students who measured very low on the initial assessments were of interest as a meaningful case, and students who scored high on the initial assessments were of interest. Cases also emerged when some abnormal behavior or tendency was observed by the researcher. Other cases tried to encompass average students. The diversity of the students selected for the study based on race and gender was comparable to the demographics of the school. The population of the school represented little ethnic diversity, though there was diversity with regard to socioeconomic level among students. A study of the cases sought to illuminate the effects of the program of interest on increasing student movement abilities and digit span (Merriam, 2009).

A convenience sample poses risks both ethically and statistically (Muijs, 2011; Vogt, 2007). In a backyard setting, it is difficult to receive informed consent without the participants feeling pressure to participate in a power situation. The study was based on the implementation of a program that was a part of the regular classroom curriculum used in the school. All the students in the classroom combination participated in the Minds-In-Motion Maze whether or not they were a part of the study. The voluntary participation in the study was the use of the assessment data gathered for use in the study. The nature of the intervention was not sensitive in any way, and every effort was made to protect students from any harm. Families were not pressured to give consent for student data to be used.

In a backyard setting, results are difficult to generalize outside of the sample, but can be used with extreme caution (Vogt, 2007). Despite this difficulty, Muijs (2011) found great value to conducting educational research in an educational setting. In qualitative study, the researcher is the tool for data collection, and frequently the researcher participates in the study in a hands-on way (Jackson & Taylor, 2007). This participation poses less threat to a population that already is comfortable with the researcher. However, observer bias can be a problem in a familiar setting, because the researcher has the potential to influence possible outcomes and selectively report outcomes. Efforts were made to reduce influencing outcomes by recording observations out of view of students, so students were not visually reminded that they were being observed. These potential limitations were indicated in the study.

A qualitative study sought to uncover as much information as possible about the topic in question intending to provide a detailed narrative description of the intervention, warranting a small sample size (Jackson & Taylor, 2007). A manageable number of research participants to work with provided a qualitative researcher the ability to discover as much information as possible about the research subjects.

This study took place in a regular education classroom containing 27 students in prekindergarten through fifth grade. Students were divided into two groups consisting of prekindergarten-first grade and second-fifth grade in the morning, and a combination of prekindergarten-fifth grade all together in the afternoon as was the structure of the school. The study encompassed 12 weeks, beginning shortly after the school year started in the fall and ending before Christmas vacation. Creswell (2009) explained the importance that the setting of a study not be artificial as it is valuable to observe participants acting naturally and responding to the environment, and the natural setting provides comfort and ease for the participants. It is valuable to conduct educational research in a school, because the study takes place in the natural setting (Muijs, 2011). Jensen (1998) highlighted the high level of confidence that is elicited from a study conducted under actual, real-life conditions in a school.

## Data Collection Procedures

Observational data was collected by the researcher during activities in the research setting (Creswell, 2007). The researcher used participant observation by collecting data as a pre-established member of the group where the research took place (Patten, 2009). Field notes were kept during maze times to track progress and record observations for later analysis and construction of meaning, though not all students were observed every day (Jackson & Taylor, 2007). Pre- and post-assessments were administered and an improvement score was calculated that helped to measure multiple areas of progress after the implementation of the Minds-In-Motion Maze 12-week program. Following this observational protocol maintained consistency.

The data was gathered during the implementation of the Minds-In-Motion Maze program with the students in the classroom. Two students from each grade level, prekindergarten to fifth grade, were case studies as a part of this study. Observational field notes were collected as students were observed while participating in the maze before, during, and one week after a twelve week implementation of the program. Pre- and post-intervention assessments were administered to students. The assessments consisted of an Auditory Digit Span Assessment (Appendix A) and a Motor Development/Visual Perception Battery of Assessments (Appendix B) developed by Minds-In-Motion, Inc. Permission was granted for the use of both tools by Minds-In-Motion, Inc. These assessments allowed for direct comparison of student abilities in the tested areas before and after the 12-week intervention.

## Field Test

A field test was conducted with two students, ages five and seven, who were not a part of the test population. They were observed for 15 minutes using the two assessment tools similar to what happened before the Minds-In-Motion Maze program was implemented in the study, with the researcher making notes during the entire process. Two instruments were used to test the observable skill level of the students. Each student was measured using the Auditory Digit Span Assessment and the Motor Development/Visual Perception Battery of Assessments. The instruments generate numerical scores the researcher was able to compare. The pre- and post-assessment data was linked so comparisons could be made. The raw observational data was also linked to the specific student for comparison.

The field notes were reviewed once providing a general sense of the whole, and then twice more before developing a preliminary list of categories, themes, and patterns. Each observation was reviewed again in more detail and five common themes emerged. The themes of balance, bilateral coordination, fine motor control, large motor control, and auditory digit span emerged from the preliminary review of data. The field test data showed three strong categories: balance, auditory digit span, and coordinated movements.

The themes were given a code and the observational data was reviewed again with the letter code placed next to the appropriate segment of the test or observational note. Qualitative data analysis is the process of making meaning from what the researcher has observed and answering the research questions of the study (Merriam, 2009). Meaning began to emerge as the themes were applied to the observational field notes.

Student E1 is a seven-year-old boy diagnosed with dyslexia. He struggles with reading and maintaining attention for lengths of time. He enjoys throwing and catching games and receives instruction twice a week in Taekwondo. During his first assessment he enjoyed the game-like feel of the large motor assessments. He scored low in auditory digit span and his balance was extremely limited. He struggled with all of the four digit numbers except two sets during the auditory digit span assessment. His auditory digit span score during the first assessment was 4.2.

Student E2 is a five-year-old girl who is very small for her age. She enjoys coloring and receives instruction twice a week in Taekwondo. During the first assessment she enjoyed repeating the numbers for the auditory digit span assessment and throwing the ball at the target. She scored 5.2 on the auditory digit span assessment. She was only able to catch one of the balls thrown to her during the first assessment, though she seemed to enjoy the activity.

Three themes were evident in the field test data gathering. The job of the researcher was to determine which themes were important and should be included in future analysis, and what additional themes would emerge as more observation took place. Creswell (2009) suggested that making sense out of the data gathered in a way that provides a greater understanding to the related field of study through the processes of data collection, analysis, reporting findings, and drawing conclusions is the purpose of research. The assessment tools were used in a pre- assessment format and no intervention or post-assessment was conducted with the field test population. Some of the following areas were revised before the study was conducted.

An efficient yet fun order for the structured assessment time was needed. Mixing the fun and the “less” fun activities kept the students engaged, and then the assessment time did not feel as much like a test. Based on this field test, an observational protocol was established to use during the study to gather pre- and post-assessment data. The order remained uniform throughout the data gathering to prevent any variation between pre- and post-assessments. The observational protocol maintained consistency between students. A script aided in the reduction of bias and discrepancies. Holding to the scripted order prevented the researcher from influencing students’ responses with bias in an effort to fulfill expectations.

The protocol followed for the Maze pre- and post-assessments consisted of the following. Students came to the maze area and were told by the researcher that they were going to do some fun activities for just a few minutes. To begin, the students were asked to demonstrate some movement items. They were first asked to skip from the wall to the door and back. Next they were asked to play catch with the researcher by tossing the beanbag back and forth five times. They were then asked to stand on the line and throw the beanbag at a target on the wall, retrieve it, and returning to the line and repeat five times. The researcher recorded the number of times the beanbag hit the target and praised the student before asking them to do it again. Then the researcher had the student stand on one foot on the balance beam while being discretely timed, repeating this twice. The student was next asked to start at one end of the balance beam and walk backwards. When they got to the other end they were asked to do it again. Then the student was directed to sit at the table and asked to repeat some numbers after they were said. After each number sequence the student was praised. When the student reached the end of the digit span assessment, they were praised for their good work and brought back to their class.

There was a sizeable amount of space for interpretation in the 1-5 scale used to measure each activity in the Motor Development/Visual Perception Battery of Assessments, so it was necessary for the same researcher to administer the pre- and post-intervention assessments. This ensured, at minimum, a consistent understanding of the scale for pre- and post-data and allowed for increased accuracy in comparisons.

The Auditory Digit Span Assessment was used to measure any growth in capacity of working memory relating to one of the research questions of this study. Ascertaining any increase in auditory digit span was one technique used to demonstrate a potential increase in capacity of working memory.

**Data Analysis**

A hallmark of case study research is the presentation of the findings of a case in context, focusing on a holistic description and explanation of the outcomes (Merriam, 2009). The data was analyzed by looking at case-based themes along with insight and discovery (Creswell, 2009; Merriam, 2009). Multiple sources of data were analyzed when discussing findings such as pre- and post-assessments, observational field notes, and teacher observations; this triangulation increased the validity and reliability of the presented data (Merriam, 2009).

Other strategies for promoting validity and reliability were used in the data analysis. The researcher provided a rich, thick description that included enough detail to contextualize the study for the reader (Merriam, 2009). The researcher spent adequate time collecting data until "saturation" became apparent (Merriam, 2009). After post-assessment data was gathered, a teacher interview was conducted. The main teacher for the students was asked to give his overall opinion of the program. The teacher was also asked to describe each student based on three areas: classroom performance, self-control, and social-emotional behavior. Follow-up questions were asked for clarification and to confirm results as various portions of data were analyzed.

A week after the post-assessments were completed, an interview with the classroom teacher was conducted to gather observational data from an additional perspective. With caution not to lead the direction of the observations, the teacher was initially asked to describe his overall opinion of the maze as implemented with the students in his class. The teacher was then asked to think about any change he saw in each student individually related to observational behavior in classroom performance, self-control, and social-emotional behavior. To conclude the interview, the teacher was again asked about his overall opinion of the maze. The interview lasted about one hour.

As the layers of the onion were peeled back, different levels of the analysis emerged as the researcher concurrently gathered data, made interpretations, and wrote findings (Creswell, 2009). Merriam (2009) suggested that once all data are collected, "there is generally a period of intensive analysis when tentative findings are substantiated, revised, and reconfigured" (p. 178). It is the job of the researcher to paint a picture of what took place during the data collection process of a study. In qualitative case study analysis "conveying an understanding of the case is the paramount consideration in analyzing the data" (Merriam, 2009, p. 203). A large amount of description was used in the writing to convey a holistic understanding of the case (Merriam, 2009). Creswell (2009) defined description as "a detailed rendering of information about people, places, or events in a setting" (Kindle Locations 3920-3921). In a multi-case study there are two levels of analysis, within-case analysis and cross-case analysis (Merriam, 2009). The researcher must first learn as much as possible about each case individually, then construct meaning across cases as themes are analyzed.

This study analyzed data collected from observations, pre- and post-intervention assessments, and a teacher interview. Observational methodology was selected to describe the characteristics of the process under review. Results were organized around each research question and the themes that emerged during the field test, and then compared to the literature to determine which findings were supported or not supported by the body of past research represented in the literature. Creswell (2009) suggested that the final level of data analysis involves interpretation of what has been observed. The ultimate goal of this study was to show the value of targeted movement activities on the brain and how these movement activities increased the working of the brain and thus a student's readiness to learn. Data was analyzed accurately and effectively to accomplish the task of transforming raw data into information that has meaning and significance and evaluate if any increase of student auditory digit span was evident.

**Limitations of Methodology**

The issue of generalizability is citied as a possible limitation of case study research because of the narrow focus on a single unit for study (Merriam, 2009). Large scale generalizations were not generated from this research. However, case studies can reveal much new information that can benefit research in the field, and the vivid descriptions of the cases provided by the researcher created an image that illustrated the situation being studied (Merriam, 2009). The reader of the case study can decide what information can be transferred and applied to their situation (Merriam, 2009).

A second limitation to qualitative, case study research is the integrity and effectiveness of the primary instrument of data collection, the researcher (Merriam, 2009). An unethical case study researcher can describe the data in a way that illustrates something the researcher wishes to show instead of what the data truly reveals (Merriam, 2009). Merriam suggested that there is no greater bias in case study research toward confirming a preconceived hypothesis than in other forms of research. It is paramount that the researcher honestly and accurately report the findings of the study (Roberts, 2010). The ethics of the investigator influence the validity and reliability of the study (Merriam, 2009). Both the reader and researcher need to be aware of these potential biases and how they relate to the presentation of findings (Merriam, 2009). Merriam also suggested that one of the strengths of this type of research is that it accounts for differences that cannot be eliminated or discounted.

In this qualitative study, the researcher was the tool for data collection, and the researcher did participate in the study in a hands-on way (Jackson & Taylor, 2007). Observer bias can be a problem, because the researcher has the potential to influence possible outcomes and make judgments about the nature of observations. The researcher recognized the potential for this and worked to observe each situation without a preconception of the outcome.

An additional limitation to this study could be the homogeneity of the sample. The teacher, researcher, and 85% of the students were of a common race. The remaining 15% represented three different ethnic origins. The sample size for this study also limited the ability to determine if the maze program was equally effective for boys and girls. The researcher not being present all of the time while all of the students went through the maze could be a limitation of the study. These potential limitations may have influenced the results of the study.

**Ethical Considerations**

The Belmont Report, 1979, on ethics in research outlines three key areas to consider when conducting a research study; respect for persons, beneficence, and justice. In accordance with the CITI training certification course, ethical practices were used throughout the research study (CITI Program, 2012). Participation did remain voluntary throughout the study. Informed consent was issued by each participant and his or her guardian, and retained as a record for the researcher. The level of risk to participants in the study was minimal. The Minds-In-Motion program had been implemented in many schools with no bodily harm posed to students (Meyer, 2012). The targeted movements were arranged with student safety at the forefront. The movements do not involve high impact or other activities that could physically harm students.

The study was based on the implementation of a program that was a part of the curriculum whether the students participated in the study or not. The voluntary participation in the study was a part of the assessment component.

Due to the need to compare pre- assessment and post-assessment data, participants were coded to maintain anonymity while providing the researcher the ability to compare the necessary data (Roberts, 2010). The coding system and any identifiable data were locked and stored away from public access (Roberts, 2010). The information they provided and all observation and assessment notes and computer files remained confidential, and no one but the researcher had access to it.

Each participant received a consent form (Appendix C) identifying the type of researcher and explaining the nature of the study. The signed consent forms were retained in a secure location.

**Chapter Summary**

The methodology for this study of targeted movement interventions employed the Minds-In-Motion Maze program in a qualitative, multi-case study approach. It included a description of the research methods and design, sample, setting, instrumentation and measures, data collection procedures, and field test. It concluded with ethical considerations, limitations and delimitations, and data analysis. Results are described in chapter 4 and organized by student with general annotations after individual data.

# Chapter IV: Results

## Nature of the Study

The study investigated the effectiveness of the Minds-in-Motion Maze targeted training activities on increasing student digit span in the regular education elementary classroom. The study sought to answer the following research questions:

1) What was the effect of the Minds-In-Motion Maze program on capacity for working memory as measured by the Auditory Digital Span assessment?

2) What were the effects of the Minds-In-Motion Maze program on an individual's movement abilities as measured by the Motor Development/Visual Perception Battery of Assessments?

3) What differences were observed by the classroom teacher at the end of the 12-week implementation of the Minds-In-Motion Maze program in the areas of classroom performance, self-control, and social-emotional behaviors?

To measure a change in cognitive function based on the capacity of working memory, this study administered a pre- and post-assessment to assess students' digit span, and any alteration in this ability after the intervention. The Minds-In-Motion Auditory Digit Span Assessment (Appendix A) is a short oral assessment requiring students to repeat back a series of digits starting with two-digit sets working up to the highest level of competency for the student. The test administrator assessed each student individually using the Auditory Digit Span Assessment. This assessment tool allowed extrapolation of descriptive statistics for discussion purposes.

The Motor Development/Visual Perception Battery of Assessments developed by Minds-In-Motion, Inc. was also used to collect observational data before and after the intervention (Appendix B). This collection of assessments was used to systematically organize observations of students' abilities in motor and visual competencies. The tool provided a structured protocol for gathering and recording data for analysis.

Observational data was collected each day by the researcher during activities in the research setting. Field notes were kept to track progress and record observations for later analysis and construction of meaning. The research log served as a daily reflective journal of highlights and challenges, and provided a record of attendance and amount of maze participation of individual students and the entire group.

The Minds-In-Motion Maze was implemented in a small, private school in the Midwest. All students in the selected grades were pre- and post-assessed using the given tools. The school chose to implement the Minds-In-Motion Maze program and collect pre- and post-assessment data for each student as a part of the new program implementation. Consent was obtained from parents to allow the data collected on their children to be used as part of this research study. This study examined 14 students in detail, two students from each grade-level, prekindergarten through fifth grade. The diversity of the students based on race and gender is comparable to the demographics of the school. The overall demographics of the student population of the school were predominately homogeneous, with 84.5% Caucasian, 8% Asian, 6% Black, and 1.5% Bi-racial. All staff members at the school are Caucasian. Every attempt was made to cover a variety of academic ability levels. The class consisted of 27 students; four prekindergarteners, two kindergarteners, four first graders, seven second graders, two third graders, four fourth graders, and four fifth graders. Students in the study were labeled based on grade-level and an identifying letter as follows: PA, PB, KA, KB, 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B.

Students proceeded through the maze each day with similar age peers. Unstructured times were utilized for maze activities for the first through fifth graders; therefore minimal classroom time was necessary for Maze participation for most grade-levels. First, fourth, and fifth graders went through the maze after they arrived at school for the day, before structured activities began. The second and third graders went through the maze after opening activities, on their way back to their classroom for work time. These groups went through each maze activity one time. There were 50 school days during the intervention time for students to participate in maze activities.

The prekindergarteners and kindergarten students went through the maze at a designated time called "playing to learn." They spent 20 minutes daily rotating through maze activities visiting each station three to four times each day for a minute or two at a time. The daily schedule for this age level allowed for this amount of time to be used for maze activities.

Students' participation was on a privilege basis. Students needed to participate in the activities the way they were intended to prevent injury and allow proper operation of the maze for all students. Some students lost their maze privilege due to disruptive behavior during the maze time. After a short break from maze activities, students returned to the maze with better adherence to the necessary safety protocols.

In order to keep from adding to the already full load of the teachers, the maze was supervised most days on a rotating basis by the researcher, a parent volunteer, or a high school volunteer. The volunteers were trained in the activities and spent most of their time tracking eyes at the eye tracking station. The supervisor could see all the students in the room but could not always stop to retrain or redirect students during the maze. The researcher was not always present when the students were participating in maze activities.

The maze included 15 stations positioned on the way to and from the maze room and in the room. The "Jelly Roll" involved students rolling on a mat on the floor in a predetermined way. Students stood on a balance board in the "Balance Board Bash," to stimulate and focus the vestibular system and concentrate on balance. Many maze activities included some vestibular stimulation with an additional focus on balance. These specific movements included "Monster Mash" where students stomped down hard on shapes laid on the floor in patterns, "Climb Every Mountain" where students step over hurdles or obstacles of varying height, "Jumping Jack Flash" where students do a standing broad jump, "Cross Walk" where students raise and touch the opposite knee while walking, "The Beam Team" where students walk in various ways on a balance beam, and "Skip to My Lou" where students skip with high raised knees. The maze also included activities that provide stimulation for the eyes: "Bean Bag Boogie" where students throw a bean bag in the air and catch it in various ways, "Eye to Eye" where students track a moving pencil topper with their eyes, and "Eye Can Converge" where students focus on each bead on a string (Meyer, 2012, p. 9-23). Maze activities in most stations increased in difficulty or intensity as the weeks progressed, as illustrated by Table 1 (Meyer, 2012, p. 32-33). If students were not able to do the more advanced activity, they could do the basic activity until they were ready to progress.

Table 1

*Minds-In-Motion Maze Activities by Week*

| Week 1 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | Skip along designated 'path' with arms swinging cross-laterally while pumping arms |
| 2. Electric Slide | Side-step along a designated wall keeping eyes, face, feet, and body facing forward but moving sideways staying as close as possible to the wall without touching it. |
| 3. Bean Bag Boogie | Throw and catch bean bag starting with two hand catch, always following bean bag with eyes |
| 4. Eye to Eye | Instructor stands in front of student and moves eye tracker in front of student's eyes approximately 14 inches away. Student follows object with eyes. Beginning pattern: two horizontal-two vertical-two circles clockwise-two circles counterclockwise- two moving in towards nose. |
| 5. Jumping Jack Flash | Do a standing broad jump between two designated lines on the floor. |
| 6. Jelly Roll | Roll on mat on floor like a pencil. |
| 7. Cross Walk | Slowly walk a given distance lifting knees high while touching alternating knee with opposite hand. |
| 8. Balance Board Bash | Stand on wooden balance board training body to suspend in balance. |
| 9. Climb Every Mountain | Step over hurdles of various heights. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance. |
| 11. Monster Mash | Stomp down hard on X's taped to floor. |
| 12. Puppy Dog Crawl | Crawl on hands and knees in a given direction. |
| 13. Eye Can Converge | Hold 'eye beads' (three beads tied 12 inches apart to a four foot string) and focus on each bead for ten seconds. |
| 14. Strong Arm Push | Stand facing a wall, then push against the wall with palms of hands with as much force as possible. |
| 15. Step Back | Walk backwards up the stairs holding on to the hand rail for safety. |

| Week 2 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | Skip along designated 'path' with right hand behind back. |
| 2. Electric Slide | Side-step along a designated wall keeping eyes, face, feet, and body facing forward but moving sideways staying as close as possible to the wall without touching it with right hand behind back. |
| 3. Bean Bag Boogie | Throw and catch bean with right hand behind back, always following bean bag with eyes |
| 4. Eye to Eye | Instructor stands in front of student and moves eye tracker in front of student's eyes approximately 14 inches away. Student follows object with eyes with right hand behind back. Beginning pattern: two horizontal-two vertical-two circles clockwise-two circles counterclockwise- two moving in towards nose. |
| 5. Jumping Jack Flash | Do a standing broad jump between two designated lines on the floor with right hand behind back. |
| 6. Jelly Roll | Roll on mat on floor like a pencil with right hand behind back. |
| 7. Cross Walk | Slowly walk a given distance lifting knees high with right hand behind back. |
| 8. Balance Board Bash | Stand on wooden balance board training body to suspend in balance with right hand behind back. |
| 9. Climb Every Mountain | Step over hurdles of various heights with right hand behind back. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance with right hand behind back. |
| 11. Monster Mash | Stomp down hard on X's taped to floor with right hand behind back. |
| 12. Puppy Dog Crawl | Crawl on hands and knees in a given direction with right hand behind back. |
| 13. Eye Can Converge | Hold 'eye beads' (three beads tied 12 inches apart to a four foot string) and focus on each bead for ten seconds with right hand behind back. |
| 14. Strong Arm Push | Stand facing a wall, then push against the wall with palm of hand with as much force as possible with right hand behind back. |
| 15. Step Back | Walk backwards up the stairs holding on to the hand rail for safety with right hand behind back. |

| Week 3 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | Skip along designated 'path' with left hand behind back. |
| 2. Electric Slide | Side-step along a designated wall keeping eyes, face, feet, and body facing forward but moving sideways staying as close as possible to the wall without touching it with left hand behind back. |
| 3. Bean Bag Boogie | Throw and catch bean with left hand behind back, always following bean bag with eyes |
| 4. Eye to Eye | Instructor stands in front of student and moves eye tracker in front of student's eyes approximately 14 inches away. Student follows object with eyes with left hand behind back. Beginning pattern: two horizontal-two vertical-two circles clockwise-two circles counterclockwise- two moving in towards nose. |
| 5. Jumping Jack Flash | Do a standing broad jump between two designated lines on the floor with left hand behind back. |
| 6. Jelly Roll | Roll on mat on floor like a pencil with left hand behind back. |
| 7. Cross Walk | Slowly walk a given distance lifting knees high with left hand behind back. |
| 8. Balance Board Bash | Stand on wooden balance board training body to suspend in balance with left hand behind back. |
| 9. Climb Every Mountain | Step over hurdles of various heights with left hand behind back. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance with left hand behind back. |
| 11. Monster Mash | Stomp down hard on X's taped to floor with left hand behind back. |
| 12. Puppy Dog Crawl | Crawl on hands and knees in a given direction with left hand behind back. |
| 13. Eye Can Converge | Hold 'eye beads' (three beads tied 12 inches apart to a four foot string) and focus on each bead for ten seconds with left hand behind back. |
| 14. Strong Arm Push | Stand facing a wall, then push against the wall with palm of hand with as much force as possible with left hand behind back. |
| 15. Step Back | Walk backwards up the stairs holding on to the hand rail for safety with left hand behind back. |

| Week 4 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | |
| 2. Electric Slide | |
| 3. Bean Bag Boogie | Throw bean bag, clap twice before catching |
| 4. Eye to Eye | Use flower pen. |
| 5. Jumping Jack Flash | . |
| 6. Jelly Roll | Roll on mat on floor like a pencil with head at opposite side of mat. |
| 7. Cross Walk | Slowly walk a given distance lifting knees high while touching alternating knee with opposite elbow. |
| 8. Balance Board Bash | Stand on wooden balance board training body to suspend in balance with both arms out to sides. |
| 9. Climb Every Mountain | Crawl under hurdles of various heights. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance with both arms out to sides. |
| 11. Monster Mash | |
| 12. Puppy Dog Crawl | |
| 13. Eye Can Converge | |
| 14. Strong Arm Push | |
| 15. Step Back | |

| Week 5<br><br>With music playing in the background | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | |
| 2. Electric Slide | |
| 3. Bean Bag Boogie | Throw bean bag, clap three times before catching |
| 4. Eye to Eye | Use India souvenir pen. |
| 5. Jumping Jack Flash | . |
| 6. Jelly Roll | Roll on mat on floor keeping head at opposite side of mat. |
| 7. Cross Walk | Increase speed slightly lifting knees high while touching alternating knee with opposite elbow. |
| 8. Balance Board Bash | Stand on wooden balance board with right arm out to side and left hand on hip. |
| 9. Climb Every Mountain | Crawl under hurdles of various heights. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance with right arm out to side and left hand on hip. |
| 11. Monster Mash | |
| 12. Puppy Dog Crawl | |
| 13. Eye Can Converge | |
| 14. Strong Arm Push | With right arm out to side and push with left palm. |
| 15. Step Back | |

| Week 6 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | |
| 2. Electric Slide | |
| 3. Bean Bag Boogie | Throw bean bag and catch on right foot. |
| 4. Eye to Eye | Use giant eraser. |
| 5. Jumping Jack Flash | . |
| 6. Jelly Roll | |
| 7. Cross Walk | Increase speed slightly lifting knees high while touching alternating knee with opposite elbow. |
| 8. Balance Board Bash | Stand on wooden balance board with left arm out to side and right hand on hip. |
| 9. Climb Every Mountain | Step over hurdles of various heights. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance with left arm out to side and right hand on hip. |
| 11. Monster Mash | Stomp on bug stickers placed on X's |
| 12. Puppy Dog Crawl | |
| 13. Eye Can Converge | |
| 14. Strong Arm Push | Push against wall with right hip. |
| 15. Step Back | |

| Week 7<br><br>With music playing in the background | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | |
| 2. Electric Slide | With arms above head. |
| 3. Bean Bag Boogie | Throw bean bag and catch on left foot. |
| 4. Eye to Eye | Use star wand and try to sing 'Twinkle, Twinkle" while eyes are tracked. |
| 5. Jumping Jack Flash | . |
| 6. Jelly Roll | Roll with arms above head. |
| 7. Cross Walk | Knees high while touching alternating knee with opposite elbow. |
| 8. Balance Board Bash | Stand on wooden balance board with arms above head. |
| 9. Climb Every Mountain | Step sideways over hurdles of various heights. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance with both hands above head. |
| 11. Monster Mash | Stomp backwards. |
| 12. Puppy Dog Crawl | Crawl backwards. |
| 13. Eye Can Converge | |
| 14. Strong Arm Push | Push against wall with left hip. |
| 15. Step Back | |

| Weeks 8 and 9 (combined due to scheduled vacation time for students for a total of six days) | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | Hopscotch pattern, two feet, one foot, two, feet, one foot. |
| 2. Electric Slide | |
| 3. Bean Bag Boogie | Throw bean bag as close to ceiling as possible without touching ceiling then catch it. |
| 4. Eye to Eye | Use feather pencil. |
| 5. Jumping Jack Flash | Jump backwards. |
| 6. Jelly Roll | Roll with legs crossed at ankles. |
| 7. Cross Walk | Keep knees high while touching alternating knee with opposite elbow. |
| 8. Balance Board Bash | Balance while tossing a bean bag. |
| 9. Climb Every Mountain | Step over large boxes. |
| 10. Beam Team | Walk sideways down the beam turning at mid-point. |
| 11. Monster Mash | Stomp backwards. |
| 12. Puppy Dog Crawl | Crawl backwards. |
| 13. Eye Can Converge | |
| 14. Strong Arm Push | Push with fingertips. |
| 15. Step Back | |

| Week 10 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | Hopscotch pattern, two feet, one foot, two, feet, one foot. |
| 2. Electric Slide | Clap hands while sliding. |
| 3. Bean Bag Boogie | Throw bean bag, touch floor then catch it. |
| 4. Eye to Eye | Use hand-shaped back scratcher. |
| 5. Jumping Jack Flash | Jump backwards. |
| 6. Jelly Roll | Roll with legs crossed at ankles and arms above head. |
| 7. Cross Walk | Keep knees high while touching alternating knee with opposite elbow. |
| 8. Balance Board Bash | Balance while tossing a bean bag and clapping once before catching. |
| 9. Climb Every Mountain | Step over large boxes. |
| 10. Beam Team | Walk along balance beam with eyes closed, turning at mid-point and walking backwards the remaining distance. |
| 11. Monster Mash | Stomp backwards. |
| 12. Puppy Dog Crawl | Bear crawl, head down. |
| 13. Eye Can Converge | |
| 14. Strong Arm Push | Cross arms to make X while pushing. |
| 15. Step Back | |

| Week 11 | Each week changes were made to some of the stations, increasing skill level and intensity. If no change is designated, the basic movements were continued as indicated in week 1. |
|---|---|
| 1. Skip to My Lou | Skip backwards. |
| 2. Electric Slide | Clap hands behind back while sliding. |
| 3. Bean Bag Boogie | Throw and catch bean bag as fast as possible. |
| 4. Eye to Eye | Use jingle bell pen. |
| 5. Jumping Jack Flash | Jump on right foot only. |
| 6. Jelly Roll | Roll as fast as possible. |
| 7. Cross Walk | Skip/hop while touching opposite knee with opposite hand. |
| 8. Balance Board Bash | Balance with eyes closed. |
| 9. Climb Every Mountain | Step over imaginary boxes. |
| 10. Beam Team | Walk along balance beam turning in circles. |
| 11. Monster Mash | Cross-over stomp. |
| 12. Puppy Dog Crawl | Army crawl. |
| 13. Eye Can Converge | Sit under eye beads; do backwards |
| 14. Strong Arm Push | Make fists and push. |
| 15. Step Back | |

| Week 12 | Reverse the order. Start at last station and do each station in reverse order. |
|---|---|
| 1. Skip to My Lou | Skip along designated 'path' with arms swinging cross-laterally while pumping arms |
| 2. Electric Slide | Side-step along a designated wall keeping eyes, face, feet, and body facing forward but moving sideways staying as close as possible to the wall without touching it. |
| 3. Bean Bag Boogie | Throw and catch bean bag starting with two hand catch, always following bean bag with eyes |
| 4. Eye to Eye | Instructor stands in front of student and moves eye tracker in front of student's eyes approximately 14 inches away. Student follows object with eyes. Beginning pattern: two horizontal-two vertical-two circles clockwise-two circles counterclockwise- two moving in towards nose. |
| 5. Jumping Jack Flash | Do a standing broad jump between two designated lines on the floor. |
| 6. Jelly Roll | Roll on mat on floor like a pencil. |
| 7. Cross Walk | Slowly walk a given distance lifting knees high while touching alternating knee with opposite hand. |
| 8. Balance Board Bash | Stand on wooden balance board training body to suspend in balance. |
| 9. Climb Every Mountain | Step over hurdles of various heights. |
| 10. Beam Team | Walk along balance beam, always turning at mid-point and walking backwards the remaining distance. |
| 11. Monster Mash | Stomp down hard on X's taped to floor. |
| 12. Puppy Dog Crawl | Crawl on hands and knees in a given direction. |
| 13. Eye Can Converge | Hold 'eye beads' (three beads tied 12 inches apart to a four foot string) and focus on each bead for ten seconds. |
| 14. Strong Arm Push | Stand facing a wall, then push against the wall with palms of hands with as much force as possible. |
| 15. Step Back | Walk backwards up the stairs holding on to the hand rail for safety. |

Each student examined by the study was reviewed based on three major themes: auditory digit span, movement abilities, and observable behavior related to classroom performance, self-control, and social-emotional behavior based on teacher interviews.

**The Students**

Student PA was an all-day prekindergartener in her first year at this school. This four-year-old female was an average size preschooler. She had an older brother also in the school. She lives over 15 miles from the school with a single mom and lives close to supportive grandparents. Prior to the intervention, PA demonstrated behaviors such as chewing on her clothing, putting her hands and other objects in her mouth, and licking things. She had to be asked to take the bean bag out of her mouth on several occasions. She would grab on to other students or maze workers. On three recorded times she licked a maze volunteer. She would frequently lean on other people or things for support.

Her pre-assessment auditory digit span was 4.8 and her post-assessment was a 5.4. Her digit span increase in 12 weeks was .6, representing a noteworthy increase. Wolfe (2001) suggested digit span grows an average of one digit over two years up to a maximum of seven digits plus or minus two. This research aligned with the findings in this study. This would assume that over a 12 week time period a digit span growth of .115 would be expected growth.

PA's movements in many areas were jerky and choppy before the intervention. Her movement abilities increased greatly in her ability to skip. She was unable to skip, even with assistance, during the pre-assessment, and she was very fluid in skipping during the post-assessment. She was also able to skip backwards for a short distance and touch opposite knee with elbow during the crosswalk. PA was only able to catch one of five bean bags tossed to her during the pre-assessment, and she was able to catch all five during the post-assessment. During the pre-assessment, PA was barely able to take one step backwards on the balance beam and averaged three steps during the post-assessment. Her abilities in the other areas remained the same after the 12-week intervention. She responded well to the increased difficulty of maze activities. She would do each new variation for a while, then she would do her own version of the activity on many occasions until reminded what she was supposed to be doing.

PA enjoyed most maze activities. She would rush to be the first in line to start the maze and would participate in most activities with a smile on her face. She did not enjoy stomping in the "Monster Mash", and would give the person who would remind her to stomp a scowling look. She frequently wore slippery dress shoes that would make stomping painful or difficult.

Her ability to sit on the rug and keep her hands to herself improved since the beginning of the intervention. She was better able to sit still and stay in one place after the intervention. She spent less time lying on the rug or across the work table after the intervention. She showed improvement in her eye contact when engaged in conversation with adults and students. After the intervention, PA still demonstrated behaviors such as chewing on her clothing and putting hands and other objects in her mouth. The frequency of these occurrences was observed less during maze times toward the end of the 12-week intervention. She participated in the maze 92% of the possible days, with the nonparticipation days being due to absences.

Student PB was a small all-day prekindergartener in his first year at the school. The four-year-old male was the second child in the family, including an older half-brother also attending the school and two younger sisters. He lived near the school with both parents.

PB was attentive to the tasks during the maze. He required very little redirection. He did what was expected to the best of his ability. He did not seem to dislike or enjoy any specific activities. He was a well-liked child by students and staff. He had a pleasant disposition.

His pre-assessment auditory span was a 3.2 and his post-assessment score was 3.6, a .4 increase in 12 weeks. His movement abilities increased greatly in his ability to skip. He was unable to skip, even with assistance, during the pre-assessment, and many of his movements were choppy and awkward. He was fluid in skipping during the post-assessment, and able to touch the opposite elbow to the knee in the crosswalk about 70% of the time.

He was only able to catch two of five bean bags tossed to him during the pre-assessment, and he was able to catch all five during the post-assessment. During the pre-assessment PB was not able to take any steps backwards on the balance beam and could only balance on the beam on one foot for about a second. During the post-assessment he averaged about four seconds at a time balancing on one foot on the beam and was able to take six to seven steps backwards on the beam. He made meaningful gains in all movement and balance abilities.

PB was absent from school due to illness or family vacation over three weeks during the 12-week intervention. Two of his absences were week-long in duration. When he would return after being gone for that length of time there was a period of re-training necessary for him to complete maze activities. He participated in the maze 64% of the time during the length of the intervention.

PB made large gains during the intervention time in his ability to focus and follow oral directions from the teacher. His primary teacher described him as more engaged in whole group and individual activities. His teacher also said he seemed to really hear and understand what was being said to him after the intervention. Directions did not seem to register in his mind before the intervention, and he would just follow what the other students did. After the intervention he was better able to keep track of what he was asked to do and his follow through also improved.

Student KA was an average-sized all-day kindergartener who was at the school as an all-day prekindergartener the previous school year. She has an older sister who also attended the school. This five-year-old female was the oldest student in the grade level and turned six at the end of the intervention. She frequently told other students what to do or where to be. She spent more time worrying about what other students were doing than if what she was doing was correct. Her movements were fluid and coordinated during all maze activities throughout the intervention. As the maze increased in difficulty she would frequently call attention to how good she was at the new variation of the activity.

Her auditory digit span rose slightly from a 4.3 to a 4.5, not a sizeable increase, though slightly larger than the .115 growth that would be expected over 12 weeks. Her movement abilities measured high during the pre-assessment and increased to the maximum level measured in all areas during the post-assessment showing a slight increase in balance, skipping, and catching the bean bag.

Her teacher described her as a leader and a bit bossy, frequently telling other students what to do. KA showed improvement in her ability to sit at her desk and work independently, although she was still prone to tell other students where they should be and what they should be doing. She is very active in gymnastics and would frequently talk about her abilities while doing maze activities. Her reading skills were advanced compared to peers in the same grade level. She participated in the maze 86% of the time during the duration of the intervention.

Student KB was a very energetic, average-size male in all-day kindergarten. This five-year-old was in his first year in the school. He had two siblings, an older step-sister and a younger half-brother. He lived with mother and step-father seven miles from the school.

His auditory digit span rose marginally from a 4 to a 4.1, not a substantial increase. His movement abilities increased in his ability to skip, which improved during the intervention, becoming more fluid. His ability to balance on one foot on the beam increased from two to three seconds in the pre-assessment to eight to nine seconds during the post-assessment, and his ability to walk backwards on the beam rose from one to two steps up to three and four steps at a time, a considerable improvement in both areas. His movement abilities in other areas did not change notably. He enjoyed the maze and always participated with a smile. He enjoyed eye tracking the most because it involved direct attention from a volunteer.

His teacher described his behavior as impulsive and hasty. KB struggled with keeping his hands to himself and controlling his behavior in the classroom and especially during transitions and in the hallway. His teacher noted slight improvement in these areas yet there was still much room for improvement.

He struggled with many of the maze activities and required very frequent redirection towards on-task behavior. A ‘three strikes’ rule was implemented, and when he violated the rules three times during a session he had to return to his desk in the classroom for the rest of the time. This strategy allowed the other students the opportunity to participate without their safety being jeopardized by KB’s out-of-control behavior. His exclusion from the maze only happened twice, and the rest of the time the ‘strikes’ helped redirect negative behaviors. When he was not being monitored directly he was rarely on task doing what he was supposed to do in the maze. He was very easily distracted by other students, things outside the window, and clothes and accessories on his own body. He would often not move efficiently from station to station. He would waste time starting an activity or get distracted while doing an activity. Many minutes were lost not focused on each activity and not participating in an intervention targeted at improving off-task behavior. Only about 25% of the time in the maze area was spent engaging in the movement activities. A one-on-one helper would have been ideal for a student with this level of distractibility. Unfortunately that was not a resource available in this school setting.

Student 1A was a first grader who has been at the school since kindergarten. This six-year-old average-size male turned seven during the program intervention. He has one younger sister.

His auditory digit span increased from a 5 to a 5.3 from the pre-assessment to the post-assessment, not a sizeable increase, though larger than the expected gain on

.115 over a 12 week time period. He showed limited improvement in throwing, catching, and balance. He showed minor improvement in skipping during the post-assessment, with movement of arms and legs becoming more fluid. His teacher described him as returning to school in the fall as a much improved reader since the end of his kindergarten school year, though he has only made minimal improvements as the school year progressed.

When asked how often he did the maze he stated that his bus was late a lot or he would forget, so he did not go much. He said he would sometimes go if someone reminded him to go. He participated in the maze 42% of the time. Students who were to participate in the maze before structured activities were to start did not participate as often as students who completed the maze during a structured time slot. The first graders were scheduled to participate in the maze before the official school day started, and late arrival at school interfered with participation on many occasions. There was also limited time for students in this situation to be reminded. The students in this situation were assigned a different time for the maze upon completion of the intervention.

In his second year at the school, Student 1B was a first grader who started at the school in kindergarten. This six-year-old average-size male turned seven during the program intervention. He has an older brother and sister also at the school and a younger sister.

His auditory digit span increased from a 5.2 to a 5.7, representing a noteworthy increase during a 12-week intervention. His movement abilities increased slightly in his ability to walk backwards on the balance beam, but the rest of the movement abilities remained static. In the classroom, he struggled to perform. 1B struggled with the reading program and did not grasp sounds and grappled with number concepts. He struggled with reversing digits and blending word sounds. His teacher referred him to district speech and special education for testing. His teacher described him as high in the effort department but lacking in the connections and noted that he struggled more sometimes than other times.

1B also arrived at school close to the start of the official school day and could not participate in the maze regularly. Maze participation was limited to the few times he was walked through to show him how to do each activity at times later in the school day and on days when he arrived at school at an earlier time with the majority of the student body. Due to poor administration of the maze schedule, 1B only participated in the maze 36% of the time during the duration of the intervention.

Student 2A was a second grader who was new to the school the year of the intervention. She had not been exposed to any of the ideas of the study that had been included by the teachers in previous years. This seven-year-old female of average size struggled in her previous school and received speech and special education services. She has one older brother also at the school and lives very close to the school with both parents. She was reluctant to do any of the assessment activities during both the pre- and post-assessments and frequently said she did not want to do an activity during the assessment times. She was assured the activities would not hurt her and they could be fun. She did not enjoy participation in the maze and would grumble while doing activities. Her dislike of the maze did lessen as the weeks progressed, and near the end of the intervention she would linger at the balance board or the bean bag toss for a few extra moments despite the increase in difficulty of those activities. Her auditory digit span increased from a 4.8 to a 5.8, a substantial increase of an entire point after the 12-week intervention. Her movement abilities increased greatly in her ability to skip. She was unable to skip, even with assistance, during the pre-assessment, yet 2A was very fluid during the post-assessment. Her ability to stand on one foot on the balance beam increased from seven to 10 seconds. Her teacher said 2A did two quarters worth of work during the time of the intervention, over double the amount required. Her handwriting has improved and she demonstrated correct formation.

2A had a stubborn attitude and wanted to do what she wanted to do. This tendency had shown some improvement after the intervention, when she became more receptive to direction and correction. She continued to demonstrate sloppy and destructive behavior in care for self and supplies. 2A showed improvement in social interactions with same age peers and interacts with a greater number of the students in the class. She participated in the maze 96% of the time and was only absent from school two days during the intervention time.

Student 2B was a second grader who had been at the school since kindergarten. This seven-year-old female is an only child of above-average size. She lived very close to the school with her grandparents, though her father lived with them also. Her mother lived out of state.

2B enjoyed the maze activities. She would work hard to meet the increasing challenge of the bean bag toss and the balance board. She was usually on task during the maze and did not require redirection.

She had a digit span increase from a 4.7 to a 5.5, a noteworthy increase of .8 after the 12-week intervention. Her movement abilities increased after the intervention. Her ability to skip improved, becoming more fluid. She was able to crosswalk with elbow touching opposite knee when she would focus on the task by the end of the intervention. She was able to balance on one foot on the balance beam for two to three seconds during the pre-assessment and an average of eight seconds during the post-assessment. Her ability to walk backwards on the beam and her throwing and catching of the bean bag remained static.

2B completed a large amount of school work during the time of the intervention, almost double what was required, though she continued to demonstrate disorganization in maintaining the materials at her desk. Her teacher stated that her quality and neatness of work increased during the intervention. 2B was more focused on the tasks she had to do. She did more work at school and had less homework by the end of the intervention. She participated in the maze every available day, though she was more focused on whether other students were doing things correctly than on her own execution of maze activities.

Student 3A was a third grader who had been attending the school since kindergarten. This eight-year-old female is smaller than average. She has one older brother who also attends the school. Though she carried no formal diagnosis, her mother described her as having Attention Deficit Disorder and dyslexia. She demonstrated many of the characteristics that are associated with these disabilities such as an extreme inability to focus, disorganization and destruction of supplies, impulsive behaviors, and reversal of numbers and letters. She was the only student in the study who was left-handed.

3A's auditory digit span increased from a 5.2 to a 5.3 during the post-assessment, less than what would be expected with maturation and 12 weeks of time passed. During the auditory digit span assessment she would repeat many of the numbers correctly but reverse the order of some of the numbers making them incorrect by means of the assessment tool. Her movement abilities and balance scored high during both the pre- and post-assessment, making it difficult to measure a gain.

Her teacher described her after the intervention as working through some of her difficulties but prone to bad days and impulsive outbursts. No real gains were recognized by the teacher, and he appeared to have difficulty separating a skillset from attitude and emotional instability. If a task was hard she would throw a fit and not do it. This would happen during maze activities or she would just not do something if she perceived it as too difficult.

Often playground disturbances would carry into the classroom and distract her from learning, though the teacher identified that the frequency of her tantrums had decreased. 3A comes from an active family. Academically she does well with large amounts of assistance from home where mom would sit with her and insist she stay focused to complete assignments. She participated in the maze every available day.

An eight-year-old male of average size, Student 3B was a third grader who was new to the school. He has three younger half-siblings. He lived close to the school with his mother and step-father, and his father lived near the family. He came to the school below grade-level academically and was working at a second grade level.

3B was an enjoyable student and participated in activities with joy and excitement, though his lack of self-confidence was evident in his participation of some of the activities at the beginning of the intervention. This hesitancy decreased greatly as the weeks progressed.

His auditory digit span started high and increased from a 5.9 to a 6.3, a noteworthy increase after the 12-week intervention. His movement ability increased slightly in his ability to skip, becoming more fluid. 3B's ability to balance on one foot on the balance beam increased from about five seconds during the pre-assessment to the maximum of 10 seconds during the post-assessment. His ability to walk backwards on the beam increased from an average of four steps to an average of five steps.

His teacher stated that the maze helped with his overall confidence to get out and play with the other kids. He was a creative student but he knew he was not so good at "kid stuff". By the end of the intervention his confidence had increased and 3B could be found participating in some of the activities the other students did at recess or in other classes. He started the school year as a non-reader with some basic phonics concepts as assessed by the classroom teacher before the beginning of the school year. By the end of the intervention he had advanced and was fluent and performing at the second grade reading level.

He struggled with asthma and had asthma attacks during physical education class. He participated in the maze 60% of the time. He was on two extended family vacations and was absent from school for 12 days during the intervention.

Student 4A was a student who has been at the school since kindergarten. This nine-year-old female was above-average in size with one younger sister, also in the school. She lived near the school with both parents.

Her auditory digit span increased from a 5 to a 6.2, an impressive increase of 1.2 after the 12-week intervention. She scored extremely high on the movement activities during both the pre- and post-assessments. This high level of ability made it difficult to measure gains in movement areas.

Her teacher described her as overcoming some lazy work habits towards the end of the intervention time. She worked above grade level in all subject areas though struggled with spelling. 4A was described as having difficulties at times related to processing skills. She is extremely active in gymnastics and softball. She was on vacation for seven days of the intervention and chose to do other things or forgot to do the maze several days when she returned from vacation. She resumed participation in the maze after being reminded. She participated in the maze 86% of the time during the duration of the 12-week intervention.

A nine-year-old male of average size, 4B was a student who has been at the school since kindergarten. He is the middle child with five siblings, living with both parents near the school. His mother suggested he had distraction problems though he worked above grade level in all subject areas. His auditory digit span increased from a 5.4 to a 6.7, an impressive increase of 1.3 after the 12-week intervention. He scored high on movement abilities in the pre- and post-assessment in the areas of skipping, throwing and catching, and standing on one foot on the balance beam. 4B did not score as high as in other areas in his ability to walk backwards on the beam in the pre- or post-assessment. He demonstrated a slight gain in this area, measured by a one-step increase in the post-assessment.

His teacher described him as struggling to keep up academically without help from family at home. He was physically active and enjoyed playing lots of sports and playground games. His desk continued to be cluttered and messy and 4B struggled to keep work neat, though some improvement had been seen in the area of neatness related specifically to written schoolwork. He did not go to the maze for some of the intervention time because of late arrival to school or being slow to complete morning tasks and missing the window of time available for the maze. He also did not seem to want to give up the time to go to the maze, though he always enjoyed the activities while he participated in them. He especially enjoyed the increased challenge each activity presented. He only participated in the maze 46% of the time during the 12-week intervention.

Student 5A is a male student of average size, age 10, who has been at the school since kindergarten. This male student is the older of two children with a younger sister who also attends the school. He lived with both parents over 10 miles away from the school.

5A never seemed to enjoy any activity, including the maze. He had a consistently melancholy disposition that very rarely changed. He always rose to the increased challenges presented in the maze, as he was able to easily master them. He did require reminders to do the activities as he was instructed, and not include his own variations.

His auditory digit span increased from a 5.9 to a 6.6, a noteworthy increase of .7 after the 12-week intervention. He scored high during the pre- and post-assessments in movement abilities in the area of skipping, throwing and catching, and standing on one foot on the balance beam. 5A showed a three-step improvement in the average number of steps he could walk backwards on the beam. The other areas did not register gains because they were at the upper limits of the scale. He was an active boy who liked sports. His teacher described his focus as improved and his overall attention to detail as being better after the intervention. He still had short stretches where he struggled to keep up for a few days, but overall he was organized and self-directed. He participated in the maze 94% of the time during the 12-week intervention.

Student 5B was a female of average size who was at the school since kindergarten, and the youngest of seven siblings who had attended the school for some or all of their schooling. She lived with both parents and two of her siblings very near the school.

The 10-year-old’s auditory digit span increased from a 5.7 to a 6.9, an impressive increase of 1.2 after the 12-week intervention. She scored high on all areas of movement ability during the pre- and post-assessment showing slight levels of measurable improvement. As maze activities increased in difficulty or novelty 5B would remark about how fun each change was or how good at the activity she was.

Her teacher described her as continuing her diligent habits in all areas. 5B was driven and exceled academically. She demonstrated strong organizational skills and was attentive to details. Her teacher described seeing an overall increase in her confidence after the intervention. She used to walk down the hall without talking to anyone, and after the intervention she was more social and outgoing. She stood taller and more poised. 5B did the maze every available day without any reminders and often assisted other same age and younger peers in completing the maze. She was the first student to go through the maze each morning and was helpful in making sure maze items were properly set up.

**Observational Data**

Engagement in maze activities seemed to decline on Mondays and Fridays. The effort and focus was less on those days, the days before or after school breaks, and around special school activities. Behavioral problems for all students were more frequent on those days also. The students were displaced or the maze was cancelled on several days during the intervention due to overscheduling of the shared space used for the maze. This eliminated seven intervention days for all students. Students had a total of 50 opportunities to participate in the maze during the intervention time period.

A summary of quantifiable data is presented in Table 2. It includes the number of days each student participated in the maze, the pre- and post-digit span, and the increase in digit span. Table 2 also includes a Y for yes, N for no, or N/A for not applicable due to upper limits reached on the assessment tool in columns for balance related movement abilities and coordinated movement abilities measured by a demonstrated increase on the Minds-In-Motion Battery of Assessments. It also includes a column that identifies a Y for yes and an N for no to identify students who showed a marked increase in overall confidence as the most noteworthy growth as specified by the cooperating teacher.

Table 2

*Quantifiable Student Data*

| Student | Times Throug h Maze | Pre-Digit Span | Post-Digit Span | Digit Span Increase | Balance Move-ments Increase Y/N | Coordin-ation Movements Increase Y/N | Confi-dence #1 Increase Y/N |
|---|---|---|---|---|---|---|---|
| PA | **46** | **4.8** | **5.4** | **.8*** | **Y** | **Y** | **N** |
| PB | **32** | **3.2** | **3.6** | **.4*** | **Y** | **Y** | **Y** |
| KA | **43** | **4.3** | **4.5** | **.2*** | **Y** | **Y** | **N** |
| KB | **45** | **4.0** | **4.1** | **.1** | **Y** | **Y** | **N** |
| 1A | **21** | **5.0** | **5.3** | **.3*** | **Y** | **Y** | **Y** |
| 1B | **18** | **5.2** | **5.7** | **.5*** | **Y** | **N** | **N** |
| 2A | **48** | **4.8** | **5.8** | **1.0*** | **Y** | **Y** | **Y** |
| 2B | **50** | **4.7** | **5.5** | **.8*** | **Y** | **Y** | **N** |
| 3A | **50** | **5.2** | **5.3** | **.1** | **Y** | **N** | **N** |
| 3B | **30** | **5.9** | **6.3** | **.4*** | **Y** | **Y** | **Y** |
| 4A | **43** | **5.0** | **6.2** | **1.2*** | **N/A** | **N/A** | **Y** |
| 4B | **28** | **5.4** | **6.7** | **1.3*** | **Y** | **Y** | **N** |
| 5A | **47** | **5.9** | **6.6** | **.7*** | **Y** | **N/A** | **Y** |
| 5B | **50** | **5.7** | **6.9** | **1.2*** | **N/A** | **Y** | **Y** |

Digit Span increases marked with an * represent noteworthy increases of more than what would be expected for students with typical maturation as suggested by

Wolfe (2001) as a one digit increase every two years, or .115 increase over 12 weeks. In most cases, students who participated in the maze more times showed larger gains in auditory digit span. The only students who did not demonstrate improvements in balance and movement abilities participated in the maze under 20 times or were diagnosed with special needs and did not always follow directions or stay engaged in maze activities. Students with diagnosed special needs showed less improvement in auditory digit span, however, improvements in balance and coordinated movements were demonstrated. The two students new to the school the year of the invention showed the largest gains.

**What Others Said About the Maze**

During an interview, the main classroom teacher for all of the students in the study was asked to describe his overall opinion of the maze as implemented with the students in his class. The teacher was then asked to think about any change he saw in each student individually related to observational behavior in classroom performance, self-control, and social-emotional behavior. To conclude the interview, the teacher was again asked about his overall opinion of the maze. He identified numerous overall improvements in the students as a whole. Students were better focused when they come back to their desks after the maze. They would sit down and get right to work focusing on what they had to do. They did not waste as much time wondering "what do I do now". The maze helped students get going right away. The increase in focus was mentioned by the teacher for 85% of the class, not just study participants, and noted as a positive outcome of maze participation.

Students did not complain about doing the maze, but complained when they did not get to do the maze for reasons such as Christmas program practice, conflict in scheduling of the maze room, or other scheduling complications. Students enjoyed the activities and overall participation in the maze, though some students who had less structured maze time would forget to go or make the choice to do other things with the time. Reminders were not always given to these students early enough to spur participation in the time designated for them to complete the maze that day. Student engagement was stressed by the classroom teacher as an extremely positive gain seen in all students.

About six weeks into the implementation of the maze, during a conversation with a classroom volunteer who has volunteered at the school for over 20 years, there was extensive discussion about the merits of movement activities on elementary children. Due to his self-described “old school” mentality, this volunteer was often skeptical of new initiatives or deviations from the “normal program” he has witnessed for 20 years. During a discussion of the potential benefits of the maze activities, the volunteer stated, “We are already seeing improvements in focus and organization in the kids.”

Students who were at the school in previous years had some exposure to concepts due to teacher interest and training in areas related to movement and the brain, but no maze or similar program had been implemented previously. In addition to the implementation of the maze, the main teacher for the group was new to the grade level group the school year the year of the intervention. The style and structure of the new teacher was much different than the previous teacher. The new teacher expected students to follow specific procedures throughout the school day. The lax tendencies related to behavior that were previously tolerated were no longer acceptable. This change in style could have been a factor in some of the areas of change seen in the students who had been at the school for previous years in the multi-grade combination structure of the school.

Multiple sources of data were used in discussing the results of this study. The pre- and post-assessments for each student were closely evaluated for any change in ability. The observational field notes and teacher observations were read and analyzed for themes and common patterns. Using these data sources and comparing them to the research questions of the study provided additional data. This triangulation increased the validity and reliability of the presented data. This study sought to show the value of targeted movement activities on the brain and how these movement activities increased the working of the brain based on the measure of auditory digit span. The data was analyzed accurately and effectively to accomplish the task of transforming raw data into information that has meaning and significance. An evaluation of the data was made to identify any increase in student capacity based on the research questions of the study.

Students in the study showed many areas of growth. Auditory digit span increased for all students in the study. A noteworthy increase of over .2 was seen in 83% of the students. Almost 30% of the students had an auditory digit span increase of over one whole digit. The largest gains were seen in fourth and fifth graders and the second grade student who was new to the school the year of the intervention.

At least 83% of the students in the study showed improvement in movement abilities related to skipping, throwing and catching, and balancing and walking on the balance beam. All students demonstrated some improvement in these areas, though the upper limits of the assessment tool were reached by some of the older students in the study, and growth was not able to be measured. The data for these two students was removed when calculating growth in this area.

Three of the students were able to perform at the top measurable level during the pre-assessment, resulting in no ability to systematically measure growth in movement ability in these areas. The largest gains were in the younger students and those students new to the school the year of the intervention. The younger students were able to demonstrate a substantial increase in movement abilities based on the Motor Development/Visual Perception Battery of Assessments developed by Minds-In-Motion, Inc. The assessment focused on fundamental skills related to basic movement abilities. The sensitivity of the tool was not able to assess changes in more advanced refining of skills that could have been involved with older or more advanced students.

In examination of field notes, student engagement would increase when the difficulty or novelty of activities would take place. When students were to toss the bean bag differently, the level of engagement in that activity would increase for the first few days after the change, despite the added challenge. When the eye tracking object would change, students would be excited to watch the new item while their eyes were being tracked. Due to the progressive nature of the changes, most changes were attainable for students. When a change was too difficult, students could do the original form of the activity but were encouraged to keep trying the new twist. This usually only happened with the way students were instructed to throw the bean bag, as some of the tasks were challenging for the younger students.

**Chapter Summary**

Chapter four presented the study results organized by case study participants following their participation in the Minds-In-Motion Maze 12-week intervention, along with comments from others related to student behavior and academic progress. Detailed student descriptions were provided to help facilitate an understanding of each case studied. Quantifiable data was presented in Table 2 as a summary of key measures. Overall observations by the classroom teacher were also noted.

Chapter five discusses how the data described previously related to student function in an educational setting and why these activities benefited students at multiple age and ability levels. It will draw parallels between this study and the cited research. Discussion of the data is organized by the research questions the study sought to examine.

# Chapter V: Discussion, Implications, Recommendations

## Overview of the Study

This multi-case study investigated the effectiveness of the Minds-in-Motion Maze targeted training activities on increasing student movement ability and digit span in the regular education elementary classroom. A discussion of results is organized first by research question based on the data collected before, during, and after a 12-week intervention. This section is followed by study conclusions, recommendations for educators, recommendations for academics and a final conclusion.

## Research Questions

The study sought to answer the following questions:

1) What was the effect of the Minds-In-Motion Maze program on capacity for working memory as measured by the Auditory Digital Span assessment?

2) What were the effects of the Minds-In-Motion Maze program on an individual's movement abilities as measured by the Motor Development/Visual Perception Battery of Assessments?

3) What differences were observed by the classroom teacher at the end of the 12-week implementation of the Minds-In-Motion Maze program in the areas of classroom performance, self-control, and social-emotional behaviors?

A pre- and post-assessment measured student's auditory digit span, and any change in auditory digit span after the intervention in order to measure a change in cognitive function based on the capacity of working memory. The Motor Development/Visual Perception Battery of Assessments was also used to systematically organize and compare observations of students' abilities in motor and visual competencies. In addition, the researcher took field notes and had a post-assessment interview with the classroom teacher. The study examined 14 students, two from each grade level prekindergarten through fifth grade, about 50% of the elementary students in the school.

Research in an educational setting is unique in that it deals with rapidly developing children who experience a multitude of stimuli each day. This presents a challenge in the measurement of an educational intervention. Which factor plays a part in or contributes to the improvement in an area is always questionable due to their growth and development.

This study examined questions related to auditory digit span, movement ability, and observable classroom behavior after the 12-week Minds-In-Motion Maze intervention.

**What is the effect of the Minds-In-Motion Maze program on capacity for working memory as measured by the Auditory Digital Span assessment?**

The auditory digit span number increased for all students in the study. Four students had an auditory digit span increase of over one whole digit, and eight students had an increase of at least half of a digit during the 12-week intervention. A one digit span increase over two years was considered typical growth in children (Wolfe, 2001). The largest gains were seen in fourth and fifth graders and those students who were new to the school the year of the intervention. The older students made more sizeable improvements in cognitive function measured through working memory by auditory digit span. Working memory measured through digit span is part of overall brain function. The interconnection of processing and storage is demonstrated in this cognitive activity, and an increase in this measure suggests an increase in this function (Wolfe, 2001). Students new to the school participated in the intervention activities for the first time, whereas students who attended the school previous years had been exposed to some of the maze activities during regular instruction time due to the experiences and beliefs of the previous teacher making the experiences less novel and less challenging for students who had previous exposure (Diamond & Hopson, 1998).

The activities of the maze increased in difficulty or intensity each week of the intervention. The novelty and stimulation of the environment could account for some of the recorded gains. A study of rats trained to navigate a complex maze showed that the rats demonstrated a significant increase in the number of synapses per nerve cell over the rats that participated in only cardiovascular exercise. This study found that learning through the obstacle course added synapses while exercise alone did not. The study stressed the need for a novel environment that presents appropriate challenges for children to thrive (Diamond & Hopson, 1998).

The Minds-In-Motion Maze program affected the capacity for working memory as measured by the Auditory Digital Span assessment for 83% of students in the study that demonstrated growth greater than what would be expected with maturation and 12 weeks, or less than one-fourth of a year, of time elapsed alone. Four students demonstrated at least two years' worth of growth based on Wolfe's (2001) discussion of average growth as one digit every two years. Based on this theory, a student would be expected to gain approximately a .115 digit increase in a

12-week time span. In this study, 12 of the 14 students demonstrated gains larger than what would be expected by maturation and time elapsed alone. None of the students in the study reached a digit span of seven though six students had a chronological age older than seven. This is shown by increases in auditory digit span from the pre-assessment performed before the intervention to the post-assessment after the 12-week intervention. Data in this study is more reflective of Wolfe's discussion of one digit span growth every two years.

**What are the effects of the Minds-In-Motion Maze program on an individual's movement abilities as measured by the Motor Development/Visual Perception Battery of Assessments?**

The Motor Development/Visual Perception Battery of Assessments showed improvements in students' movement abilities after the 12-week Minds-In-Motion Maze program. Teacher observation and researcher field notes also documented improvements in student balance and coordinated movement after the intervention.

Belgau (2004) expressed that when observing movement researchers indirectly observe the efficiency of the brain's processing ability. Smooth movements demonstrate precise timing and good integration between hemispheres of the brain whereas rigid movements show poor timing and faulty integration. The quantifiable data revealed that 83% of the students in the study showed improvement in movement abilities in all movement areas measured when the pre-assessment and the post-assessment were compared related to skipping, throwing, catching, balancing, and walking on the balance beam. All of the students in the study demonstrated observable improvement in these areas, though not all were quantifiable based on the assessment tool used. The use of a numbered scale from one to five did not leave room to demonstrate improvement for students who were at or near the top of the scale during the pre-assessment. The throwing and catching assessments that were a part of the Minds-In-Motion Battery of Assessments were very simple, not allowing students to demonstrate more complex skills or skills different from simple toss and catch. The largest gains in movement abilities were in the younger students and those students new to the school the year of the intervention. This improvement in fluidity and coordination has been suggested by Belgau (2004) to demonstrate improvement in the precise timing of coordinated movements in the brain and integration of the brain hemispheres. Wadsworth et al. (2012) also expressed that structured physical activities were necessary for students to develop gross motor skills.

The activities of the maze were changed each week to require an increase in difficulty or intensity. An increase in the difficulty level of an activity requires more precise brain timing, an increase in spatial awareness, and enhanced integration between hemispheres of the brain (Belgau, 2004). Students started at a simple level where most students were able to be successful. As maze activities gradually increased in difficulty due to the variation of the activity, it was anticipated that neural networks would be stretched to accommodate the increased demand improving the overall organization and function of the brain. This was suggested by the increased movement abilities demonstrated by students in the study.

**What differences have been observed by the classroom teacher at the end of the 12-week implementation of the Minds-In-Motion Maze program in**

**the areas of classroom performance, self-control, and social-emotional behaviors?**

The classroom teacher observed many differences in children after the 12-week implementation of the Minds-In-Motion maze program. Additional improvements were cited by the classroom teacher for the 14 students studied. One unforeseen gain seven students experienced was a "profound" increase in overall confidence based on teacher identification. Improvement in neatness and handwriting were achieved for three students as noted by the general observations of the classroom teacher. Improved handwriting was one benefit noted by other schools using the Minds-In-Motion Maze program (Meyer, 2012). No formal evaluation was used to assess handwriting in this study. Nine students in the study were individually described by the classroom teacher as being much improved in their ability to focus and complete schoolwork, and that all the students in the classroom seemed more focused, not just the ones represented in the case studies. A decrease in uncontrolled outbursts was observed in one student. This behavioral improvement could have been influenced by many other factors in the educational environment.

The classroom teacher also noted that the maze made school fun and was an activity students looked forward to when coming to school. Maze activities kept students engaged in the school community. He also said "the mood of the students" was improved when they returned to the classroom after the maze.

## Conclusions

Students in this study experienced positive gains after the 12-week implementation of the Minds-In-Motion Maze as a part of the regular educational program at a small, private mid-western school. Gains were seen in multiple movement areas, auditory digit span, confidence, neatness, and focus. The ideas of improved movement, and auditory digit span emerged as themes during the field study. These findings are consistent with the results Vidoni, et al. (2013) demonstrated in coordinated motor skills and balance after implementation of the Minds-In-Motion Maze.

The maze involved students participating in 15 movement activities each day of the intervention. As students participated in these activities the daily rehearsal of these movements increased students' skill and coordination in each area. Students walked in a variety of ways on the balance beam each day rehearsing this skill and improving their balance. Students also stood on a balance board each day further improving their balance and stimulating their vestibular system (Hannaford, 1995). Throwing and catching a bean bag each day improved the students' ability in this area and in eye-hand coordination. Daily rehearsal of the coordinated movement of skipping increased students' ability to skip. All students in the study demonstrated growth in this area of coordinated, bilateral movement. Balance was demonstrated by the ability to stand on one foot and walk backwards on the balance beam as was demonstrated by 86% of the students. Demonstration of eye-hand coordination was measured by student's ability to catch the bean bag. An increase in this was shown by 79% of students. The three students who did not show improvement were at the maximum level during the pre-assessment.

Auditory digit span was assessed before and after the 12-week Minds-In-Motion Maze intervention. All students in the study showed an increase after the intervention. The first graders, 1A and 1B, showed a small increase of a .3 and a .5 in auditory digit span. This represents a slightly more than an average gain for the 12-week time frame, which is represented as a .115 digit gain in 12 weeks (Wolfe, 2001). These two students had little observable contrast in digit span beyond what would be expected in any 12-week time frame. These students did not participate in the maze as often as other students in the study due to poor scheduling and a late morning bus. All first graders were trained how to do maze activities during the first two weeks of the intervention. After that time they were supposed to go through the maze when they arrived at school each morning. All students were not observed every day of the maze. When it was observed that these students were not participating in the maze, they were reminded to participate. In total, the first graders went through the maze about 20 times compared to nearly 50 times for the remaining students. Lack of focus while participating in maze activities may have had an influence on study results for other students. Some students in the study, KB to the greatest level, had to be refocused frequently taking away from time spent participating in the targeted activities.

Other students showed larger gains in auditory digit span. Students 4A, 4B, and 5B had impressive gains in auditory digit span, with an increase of 1.3, 1.2, and 1.3 digits respectively. Doman (1986) suggested that digit span increases on average one digit per year and correlates to the age of the student. Other research suggests on average a one digit growth over two years of time until the adult average of seven, plus or minus two digits, is reached (Wolfe, 2001). These students experienced over one digit of growth in 12 weeks. Student 2B also achieved a digit span worth of growth during the 12-week intervention. Of the remaining 10 students, four made gains greater than a .5 digit increase. In total, 12 of the 14 students made gains exceeding average the growth Wolfe suggests of .115 during the 12-week intervention time period (See Table 2).

**Implications**

The maze activities only focused on physical movement, no activities were targeted toward increasing auditory digit span. Meyer (2012) suggested this increase in working memory measured through auditory digit span correlates to the physical stimuli students experienced during the Minds-In-Motion Maze intervention. Of the students in the study, 83% showed gains higher than what would develop under regular conditions without intervention during a short period of time (Wolfe, 2001).

The teacher described an increased confidence specifically in seven of the students after the intervention. Student 5B was described as walking taller and being bolder because of the maze activities. She was also one of the students with a substantial digit span increase of 1.3. The upper-limits of the movement assessment tool were easily exceeded by this level student, though the upper-limits of the auditory digit span assessment tool were not reached by any student. 5B was described as a diligent, driven student before and after the intervention, but the added confidence observed after the intervention was a benefit for this student. The confidence of student 3B also increased during the time of the intervention. His teacher described him as more willing to get out and play with the kids on the playground after he found success participating in the maze along with them. Success in the physical activities of the maze helped build this student's confidence, which correlated to positive social interactions with his peers. An increase in self-esteem was reported by other users of the Maze program (Meyer, 2012). Student 3B also benefited with an increase in auditory digit span despite starting with a relatively high auditory digit span for his age during the pre-assessment.

Multiple students in the study made progress in neatness of schoolwork and organization of work area. Consistent with the findings of Meyer (2012), this improvement was also cited by other schools using the Minds-In-Motion Maze program. Student 2A made progress in multiple areas, but possibly the most noteworthy was in her neatness in completing work related to penmanship and erasing. She also made improvements in keeping track of supplies and keeping work clean, intact, and less crumpled and torn. Though many variables may have contributed to this area of improvement, the classroom teacher attributed it to maze participation. Student 2B also struggled to keep her work area clean and her supplies organized and accounted for at the beginning of the intervention and showed progress in this area at the end of the intervention.

One of the major benefits that the classroom teacher continued to describe as a positive outcome in the students was increased focus. Students demonstrated an increased focus immediately following completing the maze. Students returned to their work area after the maze ready to get to work. Though hard to measure or assess, an overall improvement in focus for the entire group was also noted by the teacher, and nine students were specifically described as being much more able to focus on schoolwork. Belgau (2004) described this phenomenon as an increase in proprioception, or the brains ability to properly integrate and respond to stimuli.

Many variables are present in educational settings that cannot be controlled; the maze is what was controlled in this study. The classroom teacher also stated that, in his opinion, the time the maze took was worth it even at the expense of some instructional time.

The movements that specifically target the vestibular system could be responsible for many of the positive outcomes seen in the study participants. The vestibular system holds the responsibility of keeping track of the head's position in space, furthermore challenging this system to perform targeted movements leads to improved function of the system (Belgau, 2004; Hannaford, 1995). The other responsibilities of the vestibular system are then stronger and higher functioning. These activities strengthen a student's classroom performance, self-control, social-emotional behaviors, and repetitive performance activities such as handwriting (Belgau, 2004; Hannaford, 1995; Healey, 2004; Meyer, 2012).

Multiple activities in the maze work to stimulate the students' sense of proprioception, such as the balance beam and board, rolling, pushing on the wall, skipping, cross walking, bean bags, and walking backwards up the stairs. This important sense is described by Belgau (2004) as the awareness of the position and movement of the body in space. The brain must properly integrate sensory stimuli from tactile senses relating to touch and pressure, vision, body position, and the vestibular system to engage in effective proprioceptive processing. This could be translated to observable behavior related to coordinated movements, positioning of the body in proper relationship to stimuli, and neatness of handwriting.

Esteban-Cornejo et al. (2014) described motor ability as a key component of physical fitness that is strongly related to cognition, and physical activity programs that include motor training may improve motor ability as well as academic performance.  This study related motor ability and coordinated movement, and denoted an increase in coordinated movement abilities allied with an increase in auditory digit span.

**Recommendations for Practitioners**

The Minds-In-Motion Maze represents one movement based program designed to stimulate a child's brain and increase physiological development to better prepare them for the more complex cognitive tasks involved in learning.  This is just one program developed by one person.  There are other programs available that use similar ideas and activities.  These programs do not make reference to the other similar programs.  They are not marketing their programs and information to the educational community as a whole because they are focused in their niche market to build a business or sell a product based on the concepts they use.

Much of the research done in the area of targeted movement as an intervention has been done by the creators and vendors of the products.  The creators and vendors of the products have much to gain financially with these programs and do not communicate with other vendors.  This is a disservice to students who could benefit from targeted movement interventions.  Educators could learn from many of the techniques if the information was more readily available, more empirical research was done on these programs, and the programs were not cost-prohibitive.

The Minds-In-Motion Maze program has made the effort to bring these ideas to mainstream educational settings and works to train educators in this area; however the training is limited by location and expense. Most mainstream, regular education teachers do not have access to this type of program. Other similar programs are able to extrapolate large amounts of money from parents who are looking for viable options to help their children who are struggling academically, socially, or with attention difficulties.

The maze used in this study was implemented with very little expense to the school. The items for each station were able to be made or already accessible in the classroom. The handbook was used to set-up and arrange the stations in an auxiliary classroom and the hallway. The cost involved in this intervention was not monetary, but rather related to time taken from instruction. This is a variable not able to be evaluated by this study.

All educators and leaders that influence the operation and structure of education would benefit from understanding the value of targeted movement activities and how they prepare the brain for learning (Hannaford, 1995). Movement is becoming a necessity in today's classroom. Head Start leaders stress the importance of structured physical activity to increase the mastery of fundamental motor skills (Wright & Stork, 2013). The National Association for the Education of Young Children (NAEYC) (2009) established standards indicating that movement has an impact in all domains of learning. NAEYC suggested that movement provided children with opportunities to explore their world and contributed to the development of cognitive skills and recommended the incorporation of movement skills in early childhood settings. The Montessori movement has long stood on the premise that movement and cognition are closely entwined, and that movement can enhance thinking and learning (Fuchs, 2015). Fuchs stressed that it is imperative for young children's motor development that, on a daily basis, teachers give children opportunities to develop mature movement skills within the classroom. Programs that target stimulating the vestibular system that controls spatial awareness and the students' ability to place words and letters on a page are beneficial to educational settings (Lengel, & Kuczala, 2010). Caution must be taken in implementing high-cost or time-intensive programs until further empirical research is conducted. The proper understanding and use of movement activities has the potential to make a positive difference for students.

**Recommendations for Academics**

Results from this small case study seem encouraging, but not definitive due to variables beyond the scope of this study. More research needs to be done on the important topic of movement and the brain. Additional empirical studies need to be conducted to validate the benefits that are seen following the implementation of movement programs. Studies that encompass a longer time period or encompass a larger sample size would be of great value. Seeing the long-term benefits of targeted movement activities on the brain could provide further validation of the importance of these activities in an educational setting. This study implemented a 12-week program due in part to a similar length of time used in the Vidoni, et al. (2013) study. An additional consideration was that was the length of time available starting after the rush and busyness of the first few weeks of the school year up to the week before a two week Christmas vacation. This allowed post-assessment data to be collected before a long break in maze participation that may have influenced outcomes. The school planned to continue the maze after the completion of the study. The classroom teacher said it would be a part of the program as long as he was in charge of the classroom. He saw many positive outcomes from the maze and felt there were many positive outcomes that were not measurable.

This study relied on the observations of the classroom teacher, and included any bias he may have held. In future studies, an observational protocol could be developed for the researcher to use in the classroom, removing the potential biases of the teacher.

This study did not include a detailed analysis of handwriting. Measuring handwriting before and after a similar intervention could provide concrete examples of improvement in this area. Reading growth or mathematical reasoning growth could be measured to see if improvements could be made in these areas on standardized test or similar measures. This would be based on year-long or multiple year interventions. In this study, the use of a numbered scale from one to five did not leave room to demonstrate improvement for students who were at or near the top of the scale during the pre-assessment. A different scale or movement assessment would be appropriate to measure abilities of older students. Doman's (1986) auditory digit span protocols have been used by Minds-In-Motion and this study as one way of measuring cognitive function. Future studies could benefit from an improved version of the current tool, or different instrument to measure a change in cognitive function developed by an unbiased expert.

This study used the 15 activities that were developed into the Minds-In-Motion Maze intended to increase balance and provide vestibular stimulation through activities that require simple equipment and that can be done in a regular school setting. Minds-In-Motion established these 15 activities as their Maze program. There are many other activities that are used in the Minds-In-Motion training centers or developed as part of other programs, that could be beneficial to students and incorporated into a similar center-based program: bouncing on a rebounder (mini-trampoline), tracing an infinity symbol with hand or foot or an object held by them, inverting body/getting upside-down, summersaults, spinning, and cup stacking. These activities could be incorporated into the maze or a new intervention program and studied to see if similar results were obtained. The target movement activities are the necessary element regardless of the way they are portrayed or organized. A future study could examine the benefits of a commercial program versus the use of planned targeted movement activities in the classroom.

This study was designed to include students from all educational levels represented in the selected elementary school. The school in the study is structured with multi-age classrooms and individualized curriculum. A quantitative study of the Minds-In-Motion Maze program was done by Vidoni, et al. (2013) with a large number of preschool students at a research university. In the study the researchers found that consistent engagement in the intervention activities resulted in improvement in gross motor skills that would not develop as quickly naturally with growth and maturation. They further found that structured movement time played a critical role in the development of these skills in preschoolers. Vidoni, et al. (2013)

demonstrated improvement in balance and coordination in the preschoolers after the Minds-In-Motion Maze intervention using a similar movement assessment tool. The qualitative results found in this study showed similar increases to what Vidoni et al. found. A quantitative study similar to Vidoni et al. including older elementary students with a large population and a control group could be beneficial for future researchers to help determining the benefits of a targeted movement program on that demographic.

This study was not able to measure the mental break that students experience while participating in maze activities. The time of day students went through the maze was organized to be as early in the day as possible, reflecting the zero hour physical education research conducted by Ratey (2008) that showed the mental benefits immediately followed the physical activity. The use of a movement break at a different part of the day would be another area for future study.

**Concluding Remarks**

The implementation of the Minds-In-Motion Maze intervention produced beneficial results in increased student attention, confidence, working memory measured in digit span, and motor ability in the student population represented in this case study. The school plans to continue using the Minds-In-Motion program in subsequent years with multiple grade levels for the entire school year. The teaching staff has looked for ways to make the implementation simple and the time commitment economical. Activities are arranged as efficiently as possible to get the most out of the time invested. The teacher involved in this study said he was grateful that the maze was a part of the school program and he felt it had overall benefit for all students who participated in the intervention.

This multi-case study showed the value of targeted movement activities on cognitive function as measured by digit span. Improvement was seen in 12 of the 14 students in this study, with increases ranging from what would be expected to over two years of growth during the 12-week intervention. This study supported a link between targeted movements and an increased potential to provide needed stimulation for optimal brain function (Belgau, 2004; Hannaford, 1995; Lengel & Kuczala, 2010; Meyer, 2012). Healey (2004) stated, "Physical activities are one of the child's main means of advancing physical, intellectual, and emotional growth, so you should encourage many forms of body movement" (p. 23). This sample of students at multiple grade levels demonstrated intriguing evidence of the benefits of incorporating targeted movement activities into the school day.

As the present becomes the future, understanding of the brain continues to advance. Educators are sculptors of growing minds and must be cognizant of the growing body of research that points toward the vital connection between movement and brain function. This chapter sought to make recommendations based on the data gathered with this sample population related to movement in educational settings.

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APPENDIX A

**MINDS-IN-MOTION, INC.**

# AUDITORY DIGIT SPAN ASSESSMENT

(compiled by Minds-in-Motion, Inc.; based upon protocols by Dr. Robert Doman)

**Say numbers in monotone voice…slowly….in one second intervals. Have student repeat them. Determine student's highest numerical digit span by starting with a 2 digit, then a 3 digit, and working up to the highest level of competency.**

| 2 DIGIT | 3 DIGIT | 4 DIGIT | 5 DIGIT | 6 DIGIT | 7 DIGIT |
|---|---|---|---|---|---|
| 1-6 | 2-4-1 | 9-4-2-9 | 3-9-2-1-4 | 5-2-1-6-9-2 | 3-9-2-1-4-2-8 |
| 2-9 | 5-2-8 | 6-3-1-8 | 8-9-6-4-5 | 6-9-3-8-9-4 | 8-1-6-4-5-8-4 |
| 8-3 | 9-3-6 | 5-2-3-1 | 1-4-9-3-6 | 3-2-9-1-5-6 | 1-9-4-6-2-3-1 |
| 9-5 | 6-1-9 | 6-4-9-2 | 6-3-8-4-2 | 8-6-2-4-5-9 | 6-8-3-2-4-1-9 |
| 2-6 | 4-8-3 | 1-3-4-8 | 5-2-1-9-5 | 1-4-9-1-3-2 | 5-1-9-6-9-2-3 |
| 4-2 | 5-2-6 | 2-5-6-1 | 2-8-3-6-1 | 2-6-4-3-9-8 | 2-3-8-1-6-4-3 |
| 6-1 | 8-5-9 | 4-1-9-4 | 5-4-6-2-3 | 9-5-1-2-4-5 | 8-6-4-2-3-6-5 |
| 8-5 | 6-4-2 | 8-6-5-3 | 9-5-1-2-4 | 3-6-8-4-1-6 | 9-1-5-2-4-6-1 |
| 2-9 | 1-8-3 | 9-4-2-5 | 6-3-5-8-9 | 5-2-9-1-6-4 | 6-4-3-9-8-3-8 |
| 6-3 | 3-9-1 | 3-8-6-4 | 4-9-5-2-5 | 9-8-4-2-6-3 | 4-5-8-2-5-1-3 |

**Pre-assessment** ___________ ______________ _______
**Date Score Age**

______________________
**Student name**

**Post-assessment** ___________ ______________ _______
**Date Score Age**

**Scoring notes:**
**Start with the easiest column and try a few until you find the column that seems hard for the student. Go back to the preceding column and give all of those. Then move to the harder column. Circle the ones he/she gets correct.**
**Example: If Tommy gets all (or most all) of Column 3 correct, and gets 6 right in the next column, then his score is 3.6.**

MINDS-IN-MOTION, INC.
# MOTOR DEVELOPMENT / VISUAL PERCEPTION BATTERY OF ASSESSMENTS

| Child's name | Grade | School | Date |
|---|---|---|---|

Rate the movement & circle a number: [0-lowest 5-highest]

*Sub-test 1: Visual Pursuit* *Total=*

| | | | | | | |
|---|---|---|---|---|---|---|
| **EYE TRACKING** (using pencil topper)<br>(fluidly, smoothly, with focus, following the pencil) | 0 | 1 | 2 | 3 | 4 | 5 |
| **EYE CONVERGENCE** (pencil topper)<br>(Are both eyes able to converge together and hold?) | 0 | 1 | 2 | 3 | 4 | 5 |

*Sub-test 2: Visual-Motor Control* *Total=*

| | | | | | | |
|---|---|---|---|---|---|---|
| **DRAWING LINE THROUGH CURVED PATH [with preferred hand]**<br>See attached sheet. | 0 | 1 | 2 | 3 | 4 | 5 |
| Errors: | 6+ | 6 | 4-5 | 2-3 | 1 | 0 |

*Sub-test 3: Upper-Limb Coordination* *Total=*

| | | | | | | |
|---|---|---|---|---|---|---|
| **CATCHING** (5 trials)<br>(Catching a tossed ball with both hands) | 0 | 1 | 2 | 3 | 4 | 5 |
| **THROWING** (5 trials)<br>(Throwing ball at a target taped to wall with preferred hand) | 0 | 1 | 2 | 3 | 4 | 5 |

*Sub-test 4: Bi-lateral Coordination* *Total=*

| | | | | | | |
|---|---|---|---|---|---|---|
| **SKIPPING** (across room)<br>(Assessing fluidity / smoothness; arms swinging opposite of legs) | 0 | 1 | 2 | 3 | 4 | 5 |
| **JUMPING UP & CLAPPING HANDS**<br>Child jumps straight up & sees how many times he can clap before coming back down. | 0 | 1 | 2 | 3 | 4 | 5 |

Trial 1 ____claps; Trial 2_____claps; Average_______claps

*Sub-test 5: Balance* *Total=*

| | | | | | | |
|---|---|---|---|---|---|---|
| **STANDING ON BALANCE BEAM** | 0 | 1 | 2 | 3 | 4 | 5 |
| (on preferred leg for 10 sec. max; other knee bent; head up; Hands on hips) | 0 | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 sec. |

Trial 1 _____seconds; Trial 2 ______seconds
Average_________seconds

**WALKING BACKWARD** (on balance beam)

[Heel to toe; 6 step max. per trial]
Trial 1 ______steps; Trial 2______steps;
Ave.=______steps

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5-6 steps |

*Sub-test 6: Running Speed and Agility* *Total=*

**TIMED RUNNING & RETRIEVING**

[Running 30 feet, picking up object, running back]
Trial 1 ________sec.; Trial 2________sec.
Average _________seconds

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 11+ | 9-10 | 8 | 7 | 6 | 5 & under |

*Sub-test 7: Upper-Limb Speed and Dexterity* *Total=*

**PRINTING DOTS IN CIRCLES**

[Using preferred hand for 15 seconds]

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 0 | 1-10 | 11-20 | 21-30 | 31-40 | 40+ |

**Pre-assessment** __________ ________/ 55 =_______%
**Date** **Score** (add up all of the numbered scores)

**Post-assessment** __________ ________/ 55 =_______%
**Date** **Score** (add up all of the numbered scores)

| *SUB-TESTS:* | [points] PRE-TEST SCORE [ % ] | [points] POST-TEST SCORE [%] |
|---|---|---|
| **1. VISUAL PURSUIT** | / 10 = % | / 10 = % |
| **2. VISUAL MOTOR CONTROL** | / 5 = % | / 5 = % |
| **3. UPPER LIMB COORDINATION** | / 10 = % | / 10 = % |
| **4. BI-LATERAL COORDINATION** | / 10 = % | / 10 = % |
| **5. BALANCE** | / 10 = % | / 10 = % |
| **6. RUNNING SPEED AND AGILITY** | / 5 = % | / 5 = % |
| **7. UPPER LIMB SPEED AND DEXTERITY** | / 5 = % | / 5 = % |

APPENDIX C

**Letter of Consent**

Dear Parent/Guardian of Participant,

For those that do not know me, my name is Angela Bray and I am a doctoral candidate in Education at Bethel University in St. Paul, Minnesota. I am conducting research as part of my doctoral dissertation on the Minds-In-Motion Maze movement intervention program. The research entails observations of students before, during, and after the implementation of the Minds-In-Motion Maze intervention.

The results of the study will be used for completion of my doctoral dissertation. . Your child's name and identity will not be disclosed at any time. A number, and not your child's name will identify any information collected that is used in the dissertation.

Your participation in this research is completely voluntary. The Minds-In-Motion Maze will be implemented as a part of your child's regular educational program, but recorded observations of your child will only be conducted with your written consent.

The Minds-In-Motion Maze is a movement program that has been implemented in over 200 schools. The program poses no risk to your child. There is no direct benefit to you for participating in this project, however, the results of the study may help in improving student learning at the elementary level.

You are encouraged to ask questions or raise concerns at any time about the nature of the study or the methods I am using. Please contact me at 651-235-7414 or arb52446@bethel.edu. This dissertation proposal has been reviewed and approved by the Bethel University IRB, which is a committee whose task it is to make sure that research participants are protected from harm.

Thank you for your consideration. If you understand the use of this research and agree to allow your child to participate, please sign below, and return this form to school.

Thank you,

Angela Bray

Participant's Name ______________________________________________
Parent/Guardian Signature ________________________________________
Date ____________________